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Configuration of a Directory System

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CROSS-REFERENCE TO RELATED APPLICATION

The present application is related to co-pending U.S. patent application Ser. No. 10/434,726, Attorney Docket No. MS1-1576, entitled "Relational Directory," by Kim Cameron, Max L. Benson, Matthias Leibmann, Mark Brown, and James Booth; U.S. patent application Ser. No. 10/434,725, Attorney Docket No. MS1-1532, entitled "Attribute Value Selection for Entity Objects," by Kim Cameron, Max L. Benson, Matthias Leibmann, Edward H. Wayt, Kevin Miller and James Booth; U.S. patent application Ser. No. 10/435,720, Attorney Docket No. MS1-1534, entitled "Associating and Using Information in a Metadirectory," by Max L. Benson; U.S. patent application Ser. No. 10/435,712, Attorney Docket No. MS1-1533, entitled "Preview Mode," by Kim Cameron, Max L. Benson, Derek Murman, Edward H. Wayt, Jeffrey Bisset, Jie Liu, and Jing Wu; U.S. patent application Ser. No. 10/435,708, Attorney Docket No. MS1-1554, entitled "Rules Customization and Related Methods," by Kim Cameron, Matthias Leibmann, Max L. Benson, Jing Wu, Michael Jerger, Edward H. Wayt, and Kenneth Mark; U.S. patent application Ser. No. 10/434,411, Attorney Docket No. MS1-1555, entitled "Automated Information Management and Related Methods," by Stephen Siu, Max L. Benson, and James Booth; and U.S. patent application Ser. No. 10/435,113, Attorney Docket No. MS1-1535, entitled "Declarative Rules for Metadirectory," by Kim Cameron, Max L. Benson, and James H. Booth, all of which are assigned to the assignee of the present application and filed on May 8, 2003.

TECHNICAL FIELD

The described subject matter relates generally to configuring a data processing system, and in a more particularly implementation, to configuring a directory system, such as a metadirectory system.

BACKGROUND

Companies and other organizations typically maintain information about many different aspects of the organization in order to ensure efficient operation. This organizational information (or organizational data) describes people, resources, applications, and the like, which make up the organization. For example, organizational information descriptive of an employee may include his/her name, job title, salary, telephone number, and/or internet protocol (IP) address. Organizational information describing an application may include the application's name and associated services provided by the application. Organizational information describing a resource may describe the resource as a network device (e.g., a printer), the name of the device, and capabilities provided by the network device. Many other types of organizational information may be maintained.

The organizational information is typically maintained in a number of remote data storage repositories, such as databases, directories, text files, and so on. For example, the human resources (HR) department may have a data repository of all employees in the company, with employee information. The information technology (IT) department may have a data repository of all email accounts and internet protocol (IP) addresses associated with employees, applications, resources, etc. Data in the repositories frequently overlaps, meaning that some information may be common among more than

1 one repository. In a typical organization, each of the data repositories is independently
2 maintained by the department that owns the repository. For example, the HR department
3 maintains its own employee information, while the IT department maintains its own
4 network information.

5 Because each of the various remote data repositories is independently maintained
6 by the department that owns the data repository, and there may be data common among
7 them, inconsistencies may arise among the data repositories. For example, the HR
8 department repository may have employee "John Smith," and may list an email address
9 of "johns@company.com"; the IT department may initially have John Smith's email
10 address as "johns@company.com," but may change the address to
11 "johnsm@company.com" when another employee, "John Simpson," joined the company.
12 Thus, when the IT department changes John Smith's email address in the IT repository,
13 the email address is no longer consistent with John Smith's email address in the HR
14 department repository. For many other reasons, information stored in data repositories
15 may become inconsistent within an organization. Thus, organizations typically attempt
16 to manage their various data repositories so as to keep the information in them consistent,
17 as well as up-to-date, accurate, and readily available.

18 One technique for managing an organization's data repositories and their
19 associated organizational information involves linking the multiple remote repositories,
20 while allowing each department to independently modify its own repository. A so-called
21 metadirectory system employs such a technique. A metadirectory system is essentially a
22 directory of directories or repositories. In traditional metadirectories, data from each of a
23 number of repositories is received by an associated interface that negotiates between the
24 remote repository and a central repository. The central repository includes data
25

1 representing a combination of data in all the remote repositories. Each of the interfaces
2 typically executes scripts in response to specified events, such as the hiring/firing of an
3 employee, or the changing of an IP or email address.

4 Each of the individual remote repositories may employ complex data structures,
5 schemas, and protocols for managing its stored information. The metadirectory system
6 itself therefore may also need to employ a highly complex strategy in order to interact
7 with these separate remote repositories. The complexity of the metadirectory system
8 introduces a number of challenges. Those developing the metadirectory system face a
9 first challenge in designing a metadirectory system that meets the myriad of requirements
10 imposed by the separate data repositories. Developers face a second challenge in
11 subsequently maintaining the metadirectory system so that it continues to meet the
12 changing needs of the business for which it was developed. For instance, changes in the
13 design of a remote repository may require a developer to make corresponding changes in
14 the metadirectory system to ensure that the metadirectory system continues to interact
15 with the remote repository in a desired manner. Alternatively, the business may decide to
16 add a new remote repository or delete a previously used remote repository, which again
17 requires changes to the metadirectory system. As used herein, the task of changing the
18 metadirectory system in any manner is referred to as configuring the metadirectory
19 system.
20

21 Configuring the metadirectory system is typically a very burdensome task, as a
22 developer should take great care to ensure that the changes made to one part of the
23 metadirectory system do not adversely affect another part of the metadirectory system.
24 This task is all the more troubling in view of the fact that many businesses regard the
25 integrity of their data repositories as essential to the success of their businesses. Thus,

1 mistakes made in changing the metadirectory system can have the effect of literally
2 crippling the business, resulting in loss of productivity and money. Needless to say, for
3 example, a business will not look too favorably on a developer who introduces errors in a
4 payroll system due to an errant update operation made to the metadirectory system.

5 In the computer fields, developers commonly test an upgrade on a test (or lab)
6 system prior to implementing the upgrade on the working system used by the business.
7 This working system is commonly called the production system of the business. The test
8 system typically includes the same functionality as the production system, and may have
9 access to all of the repositories used by the business, or some representative sample
10 thereof. In using this approach, the developers aim to detect and remedy any errors in the
11 upgrade prior to it being installed on the production system.

12 Nevertheless, it is not a simple task to apply this strategy to the configuration of
13 metadirectory systems. This difficulty ensues, in part, from the sheer complexity of the
14 metadirectory system. Even after reaching some assurance that the update is working
15 properly on the test system, a developer may nevertheless introduce errors in duplicating
16 the upgrade in the production system. This is because it is a difficult task to accurately
17 “fit” an upgraded piece of the metadirectory system into its proper “location” in the
18 metadirectory system. The developer must worry about how the upgraded piece impacts
19 and interacts with other pieces that have not been changed, and make appropriate
20 modifications to ensure that the system runs smoothly following an upgrade. Further,
21 there is a possibility that assumptions made in developing a new configuration on the test
22 system do not completely match the conditions present in the production system,
23 potentially resulting in a faulty upgrade. Again, the consequences of a misstep in
24 performing this task can be severe.
25

1 Accordingly, there is a need in the art for a reliable and efficient technique for
2 configuring data processing systems, such as metadirectory systems.

3 4 **SUMMARY**

5 According to one exemplary implementation, a technique is described for
6 configuring a data processing system that interacts with multiple data sources via a set of
7 respective management agents. The technique includes: (a) creating configuration
8 information used for modifying the data processing system; (b) exporting the
9 configuration information to a storage location; (c) importing the configuration
10 information from the storage location to the data processing system; and (d) applying the
11 configuration information to modify the data processing system by making a change to
12 the set of management agents.

13 Related infrastructures, data processing systems, apparatuses, computer readable
14 media, data structures, etc. are also described herein.

15 16 **BRIEF DESCRIPTION OF THE DRAWINGS**

17 A more complete understanding of the various methods and arrangements
18 described herein, and equivalents thereof, may be had by reference to the following
19 detailed description when taken in conjunction with the accompanying drawings wherein:
20

21 Fig. 1 shows an exemplary infrastructure for configuring a metadirectory system.

22 Fig. 2 shows exemplary functionality provided by the metadirectory system
23 organized into a series of layers.

24 Fig. 3 shows how the functionality of Fig. 2 can be used to implement interaction
25 between the metadirectory system and a collection of connected directory sources.

Fig. 4 shows exemplary details of a rules layer shown in Fig. 2.

Fig. 5 shows exemplary details of an executive layer shown in Fig. 2.

Fig. 6 shows how connector space and aggregated space (provided by a storage layer shown in Fig. 2) can be used to govern interaction between the metadirectory system and the connected directory sources.

Fig. 7 shows a breakdown of exemplary different operations performed at different stages in the operation of the metadirectory system.

Fig. 8 shows an overview of a method for configuring the metadirectory system.

Fig. 9 shows a process for configuring the metadirectory system by importing a new management agent.

Fig. 10 shows a process for configuring the metadirectory system by updating an existing management agent already provided by the metadirectory system.

Fig. 11 shows a process for configuring the metadirectory system by making changes to plural management agents.

Figs. 12-16 show different user interface (UI) presentations for allowing a user to interact with the metadirectory system for the purpose of configuring it.

Fig. 17 shows an exemplary computing environment for implementing a metadirectory system and/or configuration logic used to configure a metadirectory system.

DETAILED DESCRIPTION

Various methods are illustrated as being implemented in a suitable computing environment. Although not required, various exemplary methods will be described in the general context of computer-executable instructions, such as program modules, being

1 executed by a computer server and/or other computing device. Generally, program
2 modules include routines, programs, objects, components, data structures, etc. that
3 perform particular tasks or implement particular abstract data types. Moreover, those
4 skilled in the art will appreciate that various exemplary methods may be practiced with
5 other computer system configurations, including hand-held devices, multi-processor
6 systems, microprocessor based or programmable consumer electronics, network PCs,
7 minicomputers, mainframe computers, and the like. Various exemplary methods may
8 also be practiced in distributed computing environments where tasks are performed by
9 remote processing devices that are linked through a communications network. In a
10 distributed computing environment, program modules may be located in both local and
11 remote memory storage devices.

12 In some diagrams herein, various algorithmic acts are summarized in individual
13 “blocks.” Such blocks describe specific actions or decisions that are made or carried out
14 as a process proceeds. Where a microcontroller (or equivalent) is employed, the flow
15 charts presented herein provide a basis for a “control program” or software/firmware that
16 may be used by such a microcontroller (or equivalent) to effectuate the desired control.
17 As such, the processes are implemented as machine-readable instructions storable in
18 memory that, when executed by a processor, perform the various acts illustrated as
19 blocks.
20

21 The term “configuring” is used broadly herein. The term configuring may
22 encompass any change made to a data processing system, including the introduction of a
23 new part of the data processing system, the deletion of an existing part of the data
24 processing system, or the modification of an existing part of the data processing system.
25 Further, the term configuring may specifically target one or more parts of the data

1 processing system, or may globally affect the entire data processing system. The term
2 configuring also extends to an initial configuration of the data processing system.

3 This disclosure includes the following sections:

4 A. Overview of Techniques and Systems for Configuring a Metadirectory System

5 B. Overview of an Exemplary Metadirectory System

6 B.1. Exemplary Architecture of the Metadirectory System

7 B.2. Exemplary <mv-data> and <ma-data> Formats

8 C. Exemplary Techniques and Systems for Configuring the Metadirectory System

9 C.1. Overview of Export/Import Processes

10 C.2. Export Processes

11 C.3. Import Processes

12 C.4. UI Functionality

13
14 D. Exemplary Computer Environment for Implementing the Configuration
15 Techniques

16 E. Appendix: Exemplary Schemas and Rules

17 E.1. Join Rules

18 E.2. Projection Rules

19 E.3. Stay Disconnecter Rules

20 E.4. Import Attribute Flow XML Format and Runtime Behavior

21 E.5. Export Attribute Flow XML

22 E.6. Run Configuration XML Format
23
24
25

A. Overview of Techniques and Systems for Configuring a Metadirectory

System

Fig. 1 shows an environment 100 in which the configuration techniques described herein can be employed. The environment 100 includes a production environment 102 and a lab environment 104. The production environment 102 generally refers to the infrastructure used to manage a business's data on a day-to-day basis – that is, in the normal course of the business's operations. The lab environment 104 generally refers to infrastructure that does not typically play a part in the day-to-day operations of the business. Hence, the lab environment 104 may represent equipment that is operated by users “off-line” with respect to the normal course of the business's operations. In other implementations, the production environment 102 and lab environment 104 can utilize the same equipment, yet share such equipment for normal business use and off-line testing tasks.

The production environment 102 and the lab environment 104 can include any type or combination of data processing equipment. The production environment 102 is shown as including a production system 106, and the lab environment 104 is shown as including a lab system 108. In one implementation, these systems (106, 108) can represent any kind of computing system, such as a server system (e.g., a computing system running Windows Server 2003 produced by Microsoft Corporation of Redmond, Washington). Alternatively, each of these systems (106, 108) can represent a collection of computing devices coupled together via a network. Accordingly, the system entities shown in Fig. 1 are intended to represent any kind of computing functionality for performing the functions to be described below.

Fig. 1 shows that production system 106 is coupled to a collection of connected directory (CD) sources (110, 112, ... 114) (also referred to herein as remote repositories, or RR's). Such connected directory sources can represent any type of repository of information used within the business. Exemplary CD's can include Network Operating Systems and Directory Services (Microsoft Windows NT®, Active Directory®, Active Directory Application Mode, Novell eDirectory, SunONE/iPlanet directory, X.500 systems and other metadirectory products), E-mail Systems (Lotus Notes & Domino, Microsoft Exchange 5.5, etc.), Application Systems (PeopleSoft, SAP, ERP, telephone switches, XML & DSML based systems, etc.), Database Systems (Microsoft SQL Server, Oracle, IBM DB2, Informix, Sybase, OLE/DB based systems, etc.), File-based Systems (DSMLv2, LDIF, delimited, fixed width, attribute value pairs, etc.). This is merely an illustrative and non-limiting list of possible CD's. More generally, this disclosure makes reference to various commercial systems in order to provide a concrete example of one implementation of a metadirectory system; however, the configuration techniques are not limited to the use of the specific metadirectory system and associated commercial systems described herein.

Although not shown, the lab system 108 can also couple to the CD's (110, 112, ... 114), or couple to some portion thereof, or couple to some copy or version thereof. However, as stated above, the lab system 108 is not intended to interact with these CD's (110, 112, ... 114) on a day-to-day basis to perform business transactions.

Information stored in the various CD's can be managed as objects having attributes. In the context of a business, such objects typically store identity information regarding individuals, applications, and resources associated with the business. Information associated with people can include name, mailbox, salary, job title, and so forth. Information regarding

1 applications can include network addresses, lists of services, and so forth. Information
2 regarding resources can include printers, network resources, and so forth. A data store used to
3 manage these objects is referred to as a directory.

4 Both the production system 106 and lab system 108 can include functionality for
5 implementing the role of a metadirectory. A metadirectory refers to a special form of a
6 directory that can integrate and synchronize information that is stored in multiple CD's. By
7 way of overview, the basic goal of a metadirectory system is to manage and coordinate
8 identity information from the multiple CD's (110, 112, ... 114). This provides numerous
9 benefits. For instance, each of the CD's may maintain duplicative information regarding
10 various individuals, assets, or other entities. There may be inconsistencies in this duplicative
11 information. The metadirectory system allows the business to provide a unified view that can
12 cull information from multiple CD's regardless of the compatibility of the CD's. This
13 provides a convenient interface through which users can access and manage information in the
14 CD's. Further, in the case of conflicting information, the metadirectory system provides a
15 mechanism for identifying a version of duplicative information that is to serve as authoritative
16 within the business. Further still, the metadirectory system provides a mechanism for
17 propagating changes made to information in one CD to counterpart duplicative information
18 stored in another CD. The metadirectory system described herein provides yet further
19 benefits, as will be described below. In one exemplary implementation, the unique
20 configuration functionality described herein can be implemented using Microsoft's Identity
21 Integration Server (MIIS) system.

23 The production system 106 shown in Fig. 1 includes a high-level depiction of certain
24 features provided by a metadirectory system. The production system 106 includes a database
25

116 for storing the metadirectory. In one implementation, the database 116 can be implemented using Microsoft SQL Server 2000 database. The database 116 can be implemented on the same server that implements other functional aspects of the metadirectory service, or can be implemented on a different server. Various indicia can be used to identify objects stored in the database 116, including Global Unique Identifiers (GUIDs), Distinguishing Names (DN's), and so forth. Objects may also be assigned an object class and an object type.

As will be described in detail in Section B, a core portion of the database 116 stores a so-called metaverse (MV). The metaverse is a storage area that contains the aggregated identity information from multiple connected directory sources, providing a single global, integrated view of all combined objects. The metaverse objects are based on the identity information that is retrieved from the CD's.

A collection of management agents (MA's) (118, 120, . . . 122) are coupled to respective CD's (110, 112, . . . 114). Generally, an MA moves data from a CD to the metadirectory in the database 116. Further, when data in the metadirectory is modified, the MA can also export the data out to the CD to keep the CD synchronized with the metadirectory. In one exemplary implementation, the MA's are uniquely designed to handle the requirements of particular CD's. An exemplary set of CD-specific MA's can be designed to interact with the following CD's: Active Directory (AD), Active Directory Application Mode, Attribute-value pair text files, Delimited text files, Directory Services Markup Language (DSML) 2.0, Exchange 5.5, Exchange 5.5 Bridgehead, Exchange 2000 Global Address List (GAL) synchronization, fixed-width text files, LDAP Data Interchange Format (LDIF), Lotus Notes 4.6/5.0, Novell eDirectory, Sun/iPlanet/Netscape directory 4.x/5.x (with

1 “changelog” support) (referred to simply as an iPlanet directory for ease of reference below),
2 Microsoft SQL Server 7.0 & 2000, Microsoft Windows NT4 Domains, and Oracle 8i/9i.
3 This is merely an illustrative and non-limiting listing of possible CD-specific MA’s.

4 A collection of rules governs the operation of the metadirectory service provided by
5 the production system 106. These rules can be global or local. Global rules apply to all
6 objects in the metaverse. Local rules are specific to a particular management agent. For
7 instance, rules 124 govern the behavior of the metaverse stored in the database 116. Rules
8 (126, 128, . . . 130) govern the behavior of respective MA’s (118, 120, . . . 122). For instance,
9 rules may be specified that govern the import and export behavior particular to an MA.
10 Section B provides additional details regarding the role of rules in the metadirectory service.

11 The rules can be declaratively based (e.g., based on a mark-up language, such as
12 XML). A schema can be specified that governs the permissible form of a rule. The schema
13 itself can be declaratively specified (e.g., using XML). The declarative rules can also include
14 extensions that make reference to other rule-based functionality. Custom extensions can be
15 created using any .NET programming language, such as Microsoft Visual Basic, C#, and so
16 forth. These rules can be implemented as a Microsoft .NET Framework class library, or
17 dynamic link library (DLL). To facilitate illustration, the rules (124-130) are shown as
18 separate from the database 116. However, these rules can be stored in the database 116 along
19 with the object which they control.
20

21 Although not illustrated, the lab system 108 can include similar metadirectory
22 functionality to the production system 106.
23

24 With the above introduction to an exemplary metadirectory system, an overview is
25 now provided of techniques and systems used to configure such a metadirectory system. The

1 task of configuring the metadirectory system can entail any change to the production
2 environment. In one implementation, a user might want to configure the production system
3 106 by initially defining all of the rules used to govern its behavior. In another case, the
4 production system 106 may already include an operational metadirectory system, but the user
5 wishes to completely reconfigure it by revising all or some of its existing rules. In another
6 case, the user may wish to simply add another MA (and associated rule set) to the production
7 system 106 to address the introduction of a new CD in the business. Alternatively, the user
8 may wish to delete an MA from the production system 106. Still alternatively, the user may
9 wish to modify an existing MA (and its associated rule set) provided in the production system.
10 This is a limited sampling of the actions encompassed by the term "configuration" as used
11 herein.

12 Presume, to facilitate discussion, that lab system user 132 wishes to initiate a
13 configuration session using the lab system 108. The lab system 108 is generically shown in
14 Fig. 1 as including logic for modifying the metadirectory's configuration (134). Such logic
15 134 can represent any combination of software and/or firmware used to change the rules that
16 govern the operation of the metadirectory system implemented on the production system 106.
17 Such logic 134 can represent an interface utility provided by the metadirectory itself, e.g., with
18 appropriate user interface (UI) functionality that allows the user to view and modify rules.
19

20 The operations performed using the lab system 108 produce configuration information
21 136. Such configuration information 136 may comprise one or more configuration files.
22 These configuration files, in turn, can include information that will prompt the production
23 system 106 to change its rules that govern the operation of the metadirectory service. In one
24 case, a single file can be generated that will prompt the creation or modification of one MA
25

1 provided in the production system 106, as well as handle any metaverse changes required by
2 these MA-related changes. In another case, the configuration information 136 can include a
3 suite of files that govern the configuration of the entire production system 106, or a part
4 thereof. For example, this suite of files can include separate files that affect changes to the
5 MA's (or which introduce new MA's). This suite of files can also include a file that affects
6 changes to the metaverse (MV) provided by the production system 106.

7 In one implementation, the lab system 108 outputs the configuration information 136
8 to a storage location 138. The storage location 138 can physically represent a directory
9 location of the user's 132 choosing. The storage location 138 can be physically associated
10 with the lab environment 104, the production environment 106, or some other environment.
11 The outputting of the configuration information from the lab system 108 to the storage
12 location 138 is referred to herein as an export operation. To apply the configuration
13 information 138 to the production environment, a user can retrieve the configuration
14 information 136 from the storage location 138. This retrieval operation is referred to as an
15 importing operation. The lab user 132 can perform both the exporting and importing
16 operations. Alternatively, another user 140 associated with the production environment 102
17 can initiate the importing operation. The multidirectory service can provide UI specifically
18 tailored to initiate the exporting and importing operations (as will be described with reference
19 to Figs. 12 and 13). In another implementation, there need not be such a firm separation
20 between exporting and importing; a user can create the configuration information 136 and
21 directly apply it to the production system 106.
22

23 In any case, the production system 106 is shown as including configuration logic 142.
24 The configuration logic 142 generally represents any combination of software and/or
25

1 hardware for handling configuration tasks. For instance, the configuration logic can be
2 implemented as a collection of API's associated with an executive/service level of the
3 metadirectory service. The role of the configuration logic 142 is to process the configuration
4 information 136 provided by the lab system and make the changes in the production system
5 106 specified by the configuration information 136. More specifically, the configuration logic
6 142 processes the configuration information 136 in different ways depending on what changes
7 are required by the configuration information 136. The configuration logic 142 can apply a
8 first procedure in the event that the configuration information 136 prompts it to add a new MA
9 to the production system 106. The configuration logic 142 can apply a second procedure in
10 the event that the configuration information 136 prompts it to modify an existing MA already
11 provided by the production system. And the configuration logic 142 can apply a third
12 procedure in the event that the configuration information 136 prompts it to configure (or
13 reconfigure) the entire production system 106, or multiple parts thereof. Section C (below)
14 provides additional details regarding these three procedures.

15
16 The configuration logic 142 makes changes to the production system 106 on the basis
17 of the configuration information 136 in the following manner. The production system 106
18 possesses an existing configuration defined by its existing collection of rules, etc. The
19 configuration information 136 itself also contains a description of a metadirectory
20 configuration, as it was defined in the lab system 108. The existing configuration and the
21 configuration information 136 both include several constituent parts that describe the
22 configuration of different corresponding parts of the metadirectory service. Generally, the
23 configuration logic 142 modifies the existing configuration of the production system 106 by
24 performing a part-by-part modification of the existing configuration based on the
25 configuration information 136.

1 This part-by-part modification can entail performing a detailed comparison of the
2 existing configuration with the configuration specified in the configuration information 136 to
3 produce a comparison result, and then modifying the existing configuration based on the
4 comparison result. For example, based on the comparison result, the configuration logic 142
5 can be used to modify the existing configuration by only changing those parts of the
6 configuration that are "new" within the file-specified configuration information 136.

7 This part-by-part modification can also entail matching information describing the
8 existing configuration with the configuration information 136 to produce a matching result,
9 and determining whether to modify parts of the existing configuration based on the matching
10 result and various rules. These rules can vary depending on the type of MA being modified
11 and its associated CD. This matching can result in replacing certain parts of the existing
12 configuration in the production system 106 with counterpart information provided by the
13 configuration information 136. In other cases, the configuration logic 142 may decide to
14 ignore certain parts of the configuration information 136. More specifically, the configuration
15 information 136 is generated in the lab system 108 based on a model of the production system
16 106 and its associated CD's. However, the lab environment 104 may differ from the
17 production environment 102 in various respects. This difference can result in the production
18 of configuration files that are not perfectly tailored to the production system 106 in all
19 respects. During the configuration process, the configuration logic 142 can detect these
20 differences by performing the above-described matching, and can determine what changes
21 should be made (or not made) to the production system 106 based on this matching (and based
22 on the above-described rules).
23
24
25

1 The above-described piecemeal matching particularly comes into play in the handling
2 of MA partitions. Namely, an MA (and associated CD) can include multiple component parts.
3 For instance, an MA associated with a system for an international company might contain
4 different parts associated with separate business divisions in different countries. These parts
5 are referred to as partitions. An exemplary partitioned MA is an LDAP directory with
6 different domains or naming contexts. The configuration logic 142 can perform the above-
7 described piecemeal matching to ensure that the assumptions made by the lab system 108
8 regarding the CD partitions accurately correspond to the actual partitions associated with the
9 CD's available to the production system 106. This operation may entail matching partition
10 information contained in the configuration information 136 with partition information
11 extracted from the CD or the relevant existing MA (if it exists). In one example, for instance,
12 the lab system 108 may employ a separate copy of an LDAP directory from that which is
13 employed in the production system. This copy may vary slightly from the version used by the
14 production system 106. In this case, the configuration logic 142 performs the above-described
15 piecemeal matching to match up the domains/naming context of the lab LDAP directory with
16 those of the production LDAP directory.

17
18 More specifically, the configuration logic 142 can apply an automated routine to
19 attempt to automatically perform the above-described matching operations. In the event that
20 certain partitions cannot be matched, the configuration logic 142 can then activate a UI
21 presentation that allows the user to manually specify partition matches. That is, the user can
22 identify that certain partition information associated with the configuration information 136
23 pertains to partition information stored in an existing MA or in the CD.
24
25

1 Section C provides additional details regarding other unique features of the
2 configuration process.

3 The above-described configuration process has a number of benefits. First, this
4 process provides a reliable and convenient technique for transferring configuration
5 information from a lab system to a production system. In contrast, a manual duplication
6 of configuration information might introduce errors in a production system. Second, this
7 process provides a reliable and convenient technique for piecemeal introduction of
8 changes to the production system 106 based on a collection CD-specific rules. In
9 contrast, an indiscriminate en bloc replacement of portions of an existing configuration
10 with a lab-specified configuration can introduce errors in the production system, as the
11 new portions may not “fit” well with existing parts of the production configuration, and
12 might not even accurately reflect the CD environment of the production system. These
13 are merely exemplary benefits; those skilled in the art will recognize additional merits of
14 the configuration techniques described in greater detail below.

15 The above features and resultant benefits are also applicable to other types of data
16 processing systems besides directory-related systems.

18 **B. Overview of an Exemplary Metadirectory System**

20 **B.1. Exemplary Architecture of the Metadirectory System**

21 An appreciation of the above-described configuration process can best be gleaned
22 by an introductory discussion which provides greater detail regarding the metadirectory
23 system itself. However, the details provided herein are merely illustrative and non-
24 limiting. The general principles described herein can be used to configure other kinds of
25

1 data processing systems, and in, particular, other kinds of directory and multidirectory
2 systems.

3 To begin with, Fig. 2 shows a metadirectory system 202 implemented on the
4 production system 106 (of Fig. 1) in production environment 102. The multidirectory
5 system 202 interacts with an information universe 204. The information universe 204
6 includes a collection of CD's (206, 208, 210, 212) (which may correspond to the same
7 CD sources shown in Fig. 1).

8 The metadirectory system 202 itself can be conceptualized as including a plurality
9 of functional layers, including a rules layer 214, executive (or service) layer 216, and a
10 storage layer 218. The rules layer 214 can be used to specify the behavior of the
11 metadirectory system 202. For instance, this layer 214 can be used to specify the
12 metaverse and MA rule sets (e.g., rules 124-130) shown in Fig. 1. The executive layer
13 216 applies the rules in the rules layer 214 to provide a number of services for the
14 metadirectory system 202. The executive layer 216 can also implement a variety of
15 administrative functions that allow a user to interact with the metadirectory system 202.
16 The executive layer 216 optionally includes APIs and/or other interfaces to access
17 hardware and/or software functionality. The storage layer 218 stores objects in the course
18 of providing the metadirectory service.

19 More specifically, the storage layer 218 is shown as including a core storage area
20 220 and a buffer area 222. The core storage area 220 can be viewed as an aggregated
21 combination of organizational information from a number of data repositories (e.g.,
22 CD's) in the information universe 204. The core storage area 220 also implements the
23 metaverse (MV) aspects of the multidirectory system 202. The buffer storage area 222,
24 in turn, may be used as a staging area, wherein organizational data is received from one
25

1 or more CD's and processed before affecting a change in the core storage area 220. As
2 will be described in connection with later figures, the buffer area 222 is also referred to as
3 connector space (CS).

4 The exemplary storage layer 218 can be implemented using any storage
5 mechanism, such as using an SQL database in conjunction with any kind of physical
6 storage medium. In an exemplary implementation, the core 220 and/or the buffer 222 can
7 be configured as respective flat namespaces.

8 Fig. 3 illustrates how the metadirectory system 202 can interact with the
9 information universe 204. The metadirectory system 202 illustrated in Fig. 3 shows
10 additional functionality (302, 304, 306) that plays a role in the interaction between the
11 metadirectory system 202 and the CD's in the information universe 204. Namely, the
12 metadirectory system includes staging functionality 302, synchronizing functionality 304,
13 and exporting functionality 306. In the exemplary metadirectory system 202, the staging
14 functionality 302, synchronizing functionality 304, and the exporting functionality 306
15 may be part of, or work in conjunction with, the executive layer 216, to stage,
16 synchronize, and/or export information between the information universe 204 and the
17 metadirectory system 202.

18 Fig. 3 specifically illustrates the operation of metadirectory system 202 in one
19 exemplary processing scenario. This exemplary processing scenario corresponds to the
20 case where a change made in one CD (e.g., CD 206) requires a change in another CD
21 (e.g., CD 212). For instance, the metadirectory system 202 may regard an object stored
22 in CD 206 as authoritative, and the counterpart object stored in CD 212 as non-
23 authoritative. Hence, when a change is made to the object in CD 206, the metadirectory
24
25

1 system 202 will propagate information from CD 206 to the storage layer 218, and then
2 output to CD 212.

3 More specifically, information 308 from the CD 206 is communicated to the
4 metadirectory system 202. The exemplary staging functionality 302 buffers the
5 information 308 in the buffer 222 in accordance with rules in the rules layer 214. The
6 synchronizing functionality 304 may synchronize (e.g., reconcile) the information 308
7 with other information in the metadirectory system 202 according to rules in the rules
8 layer 214. The exemplary synchronizing functionality 304 may include a synchronizing
9 engine that performs various synchronizing functions. From the buffer 222, an
10 association may be made between the information 308 in the buffer 222 and information
11 in the core 220. This may entail moving the information 308 into the core 220. The
12 information 308 can then be moved out of the core 220 again into the buffer 222, where it
13 is prepared to be exported out to the remote repository 212. The exemplary export
14 functionality 306 exports (e.g., propagates) the information out to target CD 212
15 according to the rules of the rules layer 214, thereby ensuring that CD 206 and CD 212
16 have consistent information.

17 As discussed in more detail below, in one implementation, objects in the buffer
18 222 can constitute connector objects or disconnecter objects. A connector object is an
19 object that is linked to an object in the core 220. A disconnecter object is an object that is
20 not linked to an object in the core 220. By linking, or not linking, objects in the buffer
21 222 to objects in the core 220, according to rules in the rules layer 214, unique
22 combinations of data objects and attributes can be designed into the core 220, whereby
23 the core 220 may be considered a rules-directed aggregate of information from the
24 information universe 204. In this exemplary implementation, utilizing connector objects
25

1 and disconnector objects, the buffer 222 may be referred to as a connector space, and the
2 core 220 may be referred to as an aggregate space.

3 **Rules Layer**

4 Fig. 4 illustrates the exemplary rules layer 214 shown in Figs. 2 and 3. The
5 exemplary rules layer 214 includes declarative rules that may be applied to data from one
6 or more data repositories for aggregating the data. A particular implementation of the
7 rules layer 214 includes one or more schemas (402, . . . 404) , and/or one or more
8 dynamic-link libraries (DLLs) (406, . . . 408), which are used to ensure that information
9 flows into, within, and out of, the metadirectory system 202 in accordance with specified
10 metadirectory protocols. The use of schemas (402, . . . 404) represents only one
11 mechanism for assuring conformance to metadirectory policies; other mechanisms
12 besides schemas may be used instead of, or in addition to, schemas without deviating
13 from the functional principles described herein.

14 Each of the exemplary schemas (402, . . . 404) provides a model or blueprint for
15 describing the structure of information processed by the metadirectory system 202. The
16 schemas (402, . . . , 404) also include criteria specifying how data is processed in the
17 metadirectory system 202. In general, a separate schema may be developed and applied
18 at any place within the metadirectory that information crosses a boundary. For example,
19 with regard to the metadirectory 202 of Fig 3, an import schema may be applied to the
20 information 308 when the information 308 is received from the remote repository 206.
21 As another example, a core schema may be applied to the information 308 when it is
22 moved from the buffer 222 into the core 220. Schemas (402, . . . 404) may hold
23 information such as system configuration information, data format specifications, and so
24
25

on. As mentioned above, a markup language, such as XML, can be used to express the schemas (402, . . . 404).

More specifically, in an exemplary implementation, the metadirectory system 202 employs the following schemas: a) a management agent (MA) schema; b) a remote repository schema; c) a connector filter schema; d) a join schema; e) a project schema; f) an export attribute flow schema; g) a run configuration schema; h) a deprovisioning schema; i) an import attribute flow schema; and j) a metadirectory core schema.

The MA Schema (described in more detail below) specifies criteria for MA interactions with its associated CD. The remote repository (RR) schema models the structure of data received and processed by a management agent. For example, the RR schema may define the object types and attributes used by the remote repository. The connector filter schema models a rules engine filter that is employed by a synchronization engine during importing and/or exporting of data objects. The join schema models one or more rules for joining an object in a metadirectory buffer (e.g., the buffer 222 in Fig. 2) with an object in a metadirectory core (e.g., the core 220 in Fig. 2).

The project schema models one or more rules for projecting an object into a metadirectory core (e.g., the core 220 in Fig. 2). The export attribute flow schema models one or more rules for associating an attribute in a metadirectory core (e.g., the core 220 in Fig. 2) with an object in a metadirectory buffer (e.g., the buffer 222 in Fig. 2). The run configuration schema identifies various ways in which an MA is to run, e.g., as specified by a customer.

The import attribute flow schema describes how attribute values should flow from an object in a metadirectory buffer (e.g., the buffer 222 in Fig. 2) to an object in a metadirectory core (e.g., the core 220 in Fig. 2). The core data schema models the layout

1 of the data in the core 220 in terms of different object types and attributes associated with
2 these different object types.

3 The DLL's (406, . . . 408) include sets of rules and/or specifications for managing
4 data. For instance, an exemplary DLL 406 can include rules extensions that can be used
5 by the metadirectory system 202 to combine data from two source attributes (e.g.,
6 surName and givenName) and flow this data to one target attribute (e.g., displayName).
7 The DLL's are useful in implementing custom rules to supplement the declarative rules
8 governed by the schemas (402, . . . 404).

9 In an exemplary implementation, the following types of rules may be specified in
10 the rules layer 214, using schemas, or otherwise: a) connector filter rules; b)
11 deprovisioning rules; c) export attribute flow rules; d) import attribute flow rules; e) join
12 rules; f) projection rules; and g) provisioning rules. Other rules may be implemented as
13 may be useful to a particular metadirectory design. Brief descriptions of the rules
14 mentioned above are as follows.

15 *Connector filter rules (also called disconnecter rules):* These are rules that
16 specify prevention of linking (connecting) objects in the metadirectory buffer to objects
17 in the metadirectory core.

18 *Deprovisioning rules:* These are rules that specify how a metadirectory buffer
19 object is processed after it has been disconnected (i.e., unlinked) from a metadirectory
20 core object.

21 *Export attribute flow rules:* Export attribute flow refers to the process of flowing
22 attributes of objects in the metadirectory core to objects in the metadirectory buffer.
23 Export attribute flow rules specify the process of export attribute flow.
24

25

1 *Import attribute flow rules:* Import attribute flow refers to the process of flowing
2 attributes of objects in the metadirectory buffer to objects in the metadirectory core.

3 Import attribute flow rules specify the process of import attribute flow.

4 *Join rules:* These are rules that specify the process of linking an object in the
5 metadirectory buffer to an object in the metadirectory core.

6 *Projection rules:* These are rules that specify the process of creating an object in
7 the metadirectory core and linking the created object to another object in the
8 metadirectory buffer.

9 *Provisioning rules:* Provisioning is the process of creating, renaming, and/or
10 deprovisioning objects in the metadirectory buffer based on a change to an object in the
11 metadirectory core. Provisioning rules specify the process of provisioning.

12 **Executive Layer**

13 Fig. 5 is a block diagram illustrating an exemplary executive layer 216 for use in
14 the metadirectory system 202. In general, the executive layer 216 includes hardware,
15 firmware, or computer-executable code modules (or any combination thereof) to
16 implement one or more metadirectory services. The exemplary modules in the executive
17 layer 216 are suitable for execution on a virtual machine, runtime engine, and the like,
18 and are thereby useable in a .NET® environment.

19 The exemplary executive layer 216 includes a synchronization engine 502, which,
20 in turn, includes a rules engine 504. The executive layer 216 also includes one or more
21 management agents (506, 508, . . . 510). The executive layer 216 also includes
22 administrative logic 512, which, in turn, includes the configuration logic 142 introduced
23 in Fig. 1. The executive layer 216 may also include Input/Output (I/O) logic 514.
24
25

1 The exemplary synchronization engine 502 performs synchronization of objects
2 in the metadirectory buffer 222 and/or the metadirectory core 220. Synchronization
3 refers to a process of maintaining consistency among multiple sources of data. In the
4 context of an exemplary metadirectory system, synchronization involves utilizing
5 attribute flow precedence to combine similar data into a final version that is stored in the
6 metadirectory core 220. This data is then exported from the metadirectory core 220 to
7 remote CD's.

8 The exemplary synchronization engine 502 may include the rules engine 504 as part
9 thereof. An exemplary rules engine 504, in conjunction with the rules in the rules layer 214,
10 provide rules analysis functions that direct the creation of objects and the flow of attributes
11 within the metadirectory system 202. For example, the rules engine 504 may analyze
12 connector filter criteria of a buffer object to determine whether the buffer object should be
13 connected (e.g., joined or projected) to an object in the metadirectory core 220.

14 The one or more exemplary MA's (506, 508, . . . 510) communicate with CD's to
15 receive data objects, stage the objects, and transfer data objects out to the CD's. The
16 exemplary MA's (506, 508, . . . 510) convert repository information received in one
17 format (e.g., Active Directory®, Oracle®) into an isomorphic form, such that all data in
18 the buffer is in a common form. Each of the exemplary MA's (506, 508, . . . 510) has a
19 user interface (UI) associated with it, whereby a user can access an MA. Via an MA UI, a
20 user may cause the MA to perform a specified run (e.g., execute a task), such as an
21 import run or an export run. The user can also read and update various information (e.g.,
22 version, configuration, description) associated with an MA through an MA UI.
23

24 Applications may also communicate with MA's via application programming
25 interfaces (APIs) provided by the I/O logic 514. In addition to providing APIs, the

1 exemplary I/O logic 514 performs standard input/output tasks to communicate from the
2 metadirectory to one or more remote CD's. The exemplary I/O logic 514 implements and
3 supports any communications protocols suitable to the design, such as, but not limited to,
4 Distributed Component Object Model (DCOM), Windows® Management
5 Instrumentation (WMI), Hypertext Markup Language (HTML), and Simple Object
6 Access Protocol (SOAP).

7 Finally, the administrative logic 512 generally represents any functionality by
8 which a user can interact with the metadirectory system 202 and control its operation.
9 For instance, the administrative logic 512 includes user interface logic for providing one
10 or more user interface presentations that allow a user to interact with the metadirectory
11 system 202. Such UI enables a user to access, update, and otherwise interact with the
12 metadirectory modules used in the metadirectory system and the data therein. Reference
13 to various "pages" in the ensuing discussion pertains to various UI presentations that
14 facilitate user interaction with the metadirectory service. The administrative logic 512
15 also includes the configuration logic 142 as part thereof. The configuration logic
16 coordinates the import configuration tasks described in Section A above, and to be
17 elaborated on in Section C below.

18 **Overview of Operation**

19 Figs. 6 and 7 provide information regarding how the features described in Figs. 1-
20 5 operate. To begin with, Fig. 6 is a block diagram illustrating an exemplary environment
21 600 for use in a metadirectory scenario. The exemplary environment 600 includes a
22 human resources (HR) remote directory (RD) 602, an information technology (IT) RD
23 604, and a telephone RD 606. The HR RD 602 is in operable communication with a first
24 management agent (MA1) 608. The IT RD 604 is in operable communication with a
25

1 second management agent (MA2) 610. The telephone RD 606 is in operable
2 communication with a third management agent (MA3) 612.

3 MA1 608, MA2 610, and MA3 612 are in operable communication with storage
4 614. The storage 614 is an exemplary implementation of the storage layer 218, shown in
5 Fig. 2. The exemplary storage 614 is partitioned, or otherwise divided, into a first
6 namespace, called a connector space (CS) 616, and a second namespace, called an
7 aggregated space (AS) 618. The CS 616 is an exemplary implementation of the
8 metadirectory buffer 222, shown in Fig. 2. The AS 618 is an exemplary implementation
9 of the metadirectory core 220, shown in Fig. 2.

10 The connector space 616 is partitioned, or otherwise divided, into one or more
11 connector space regions that are used by the MA's. MA1 608 communicates with a first
12 connector space region (CS1) 620. MA2 610 communicates with a second connector
13 space region (CS2) 622. MA3 612 communicates with a second connector space region
14 (CS3) 624.

15 Each of the MA's uses the MA's associated connector space regions to import,
16 and otherwise process objects from the MA's associated RD. For example, MA1 imports
17 objects from the HR RD 602 and populates CS1 620 with the imported objects. The
18 MA's may import objects from the RDs at any time. For example, the MA's may import
19 objects periodically, or upon the occurrence of a specified event, such as power-up, or
20 user request. Each of the MA's may import objects independently from the other. In one
21 exemplary implementation, MA2 610 imports objects from IT RD 604 whenever IT RD
22 604 powers up, while MA3 612 imports objects from telephone RD 606 once per day. In
23 another exemplary implementation, a user may initiate a simultaneous import at MA1,
24 MA2, and MA3.
25

Each of MA1 608, MA2 610, and MA3 612, has a schema, schema 626, schema 628, and schema 630, respectively, associated with the MA. The schemas each may have information, such as rules or data filters, that are specific to the MA associated with the schema. The exemplary schemas, 626, 628, and 630 may or may not be stored in the storage 614. In a particular implementation, the schemas are stored in a separate storage area that is accessible to the MA's and a synchronization engine.

To illustrate an exemplary metadirectory operation, an exemplary scenario is described. The exemplary HR RD 602 transmits one or more objects to the MA1 608. The MA1 608 populates the CS1 620 with the one or more HR objects 632 that the MA1 608 receives from the HR RD 602. The MA1 608 may transform, or otherwise format the one or more received HR objects 632 according to rules specified in the schema 626. Similarly, the exemplary IT RD 604 transmits one or more IT objects to the MA2 610. The MA2 610 populates the CS2 622 with the one or more IT objects 634 that the MA2 610 receives from the IT RD 604. The MA2 610 may transform, or otherwise format the one or more received IT objects 634 according to rules specified in the schema 628.

The exemplary HR objects 632 and the IT objects 634 may be aggregated into the aggregated space (AS) 618 during a synchronization process. For example, an HR object 636 may be joined with an exemplary aggregated object 638, which corresponds to the HR object 636. The aggregated object 638 may correspond to the HR object 636 if the two objects are person objects, having the same "name" value for their "name" attributes.

Likewise, an IT object 640 and a Tele object 642 may be joined to the aggregated object 638. After the HR object 636, the IT object 640, and the Tele object 642 are joined to the aggregated object 638, attributes of the objects 636, 640, and 642 may be imported to the aggregated object 638. For example, the "name" attribute of the HR

1 object 636 may be imported to the aggregated object 638, the “e-mail address” attribute
2 of the IT object 640 may be imported to the aggregated object 638, and the “home
3 telephone” attribute of the Tele object 642 may be imported to the aggregated object 638.

4 Attributes of the aggregated object 638 can be exported to joined objects in the
5 connector space 616. For example, the “name” attribute of the aggregated object 638
6 may be exported to the IT object 640 and the Tele object 642. As another example, the
7 “e-mail address” attribute of the aggregated object 638 may be exported to the HR object
8 636 and the Tele object 642. As a further example, the “home telephone” attribute of the
9 aggregated object 638 may be exported to the IT object 640 and the HR object 636. After
10 the attributes are exported, and the objects are synchronized, the HR objects, the IT
11 objects, and the Tele objects may be transmitted to the HR RD 602, IT RD 604, and Tele
12 RD 506, respectively.

13 Fig. 7 illustrates an exemplary “organizational information management process”
14 (OIMP) 700 that can be implemented in an environment such as the environment shown
15 in Fig. 2-6. The exemplary OIMP 700 includes staging (e.g., staging 302 of Fig. 3)
16 synchronizing (e.g., synchronizing 308 of Fig. 3), and exporting (e.g., exporting 306 of
17 Fig. 3), as well as other data processing that facilitates data integrity across more than one
18 connected information source.

19 Such additional processes include, for example, data aggregating 702, and
20 account managing 704. Further, such additional processes may have sub-processes. For
21 example, data aggregating 702 may include joining 706, projecting 708, importing
22 attributes 710, and join resolving 722. Joining 706, for example, is a process that may
23 involve establishing a service to determine whether an attribute of an object in the
24 connector space 620 will be joined with an object in the aggregated space 618. Account
25

managing 704 may include provisioning 712, deprovisioning 714, exporting attributes 716, and object deleting 724. Staging 302 includes a data forming process 718 and a connector filtering process 720. Exporting 306 includes a data transforming process 726.

In general, such processes and/or sub-processes may be carried out by any of a variety of modules described herein, including, one or more management agents (MA), a synchronization engine (SE), a rules engine (RE), or an MA controller. Any or all of such modules carry out the exemplary processes shown in Fig. 7 in accordance with rules and/or specifications. Such rules and/or specifications may be flexible and extensible and may be designed to ensure that the most valued, most correct, and/or user-selected data reside in the aggregated space 618 and in one or more connected information sources 604, as appropriate to the particular setting.

In some implementations of the exemplary metadirectory 202 the processes in the exemplary OIMP 700 are executed in a relatively well-defined sequence; that is to say, the various parts of the exemplary OIMP 700 are not performed at random, haphazardly, or in total separation from each other. Many of the processes performed with respect to the OIMP 700 are done as specified in rules, as discussed throughout.

B.2. Exemplary <mv-data> and <ma-data> Formats

The configuration information 136 identified in Fig. 1 can include an MV.XML file (that contains changes that affect the metaverse), and also can contain a number of management agent (MA) files that each represent one management agent (MA). The file name for each MA consists of the prefix "MA," followed by the MA's id. The lab system 108 can store these files with a read-only attribute so that they cannot be accidentally modified. The following excerpt identifies an exemplary listing of configuration files:

07/08/2003 08:23 AM	10,457 MA-{2EC39297-5D21-4CAE-
8191-9E29AB0DD482}.XML	
07/08/2003 08:23 AM	283,447 MA-{BA581110-8A6F-4BA4-
8135-FA1684FB6D4F}.XML	
07/08/2003 08:23 AM	20,651 MV.XML

However, before the details regarding the configuration process itself are disclosed, additional information is provided regarding the XML formats used in the XML files identified above. More specifically, the configuration of the production system 106 involves the creation and processing of two fragments: <ma-data> and <mv-data>. An exemplary composition of these fragments is set forth in the following sections.

The <mv-data> XML element

The <mv-data> XML format can have the following exemplary high-level composition:

```
<mv-data>
  <format-version>1</format-version>
  Versioning information
  MV rule configuration
  Password sync configuration
</mv-data>
```

This format contains an element named "format-version" which provides the version of XML formatting of this element.

The above-referenced versioning information may include the following elements:

```
<version>5</version>
  <schema>
    . . .
  </schema>
  <import-attribute-flow />
  <provisioning type="none" />
  <mv-deletion />
```

```
1      <extension />  
2      <password-change-history-size />
```

3 The version information generally conveys the version of the MV configuration.
4 Higher numbers indicate later versions of the MV configuration. When the configuration
5 logic 142 updates the MV, the old version number that the edit is based on is passed in. If this
6 number is less than the current version stored in the metadirectory database 116, then the
7 modification will fail. This behavior is designed to ensure that plural users that are
8 concurrently editing the MV will not conflict with each other.

9 The schema element referred to above contains the schema of the metaverse. The
10 schema can be implemented in DSML with extensions. The schema defines all attributes
11 referred to by elements, such as import-attribute.

12 The import-attribute-flow element specifies the import attribute flow rules that govern
13 how attributes of connector space (CS) objects are transferred to MV objects during import.

14 The provisioning element calls a provisioning script to handle object creation and
15 deletion in all CD's. If the tag is missing or if the type attribute is "none," it means that no
16 provisioning is specified for the installation of the metadirectory system.

17 The mv-deletion element specifies the import attribute flow rules that govern how
18 attributes of connector space (CS) objects are transferred to MV objects during import.

19 The extension element provides details regarding how to run an MV extension.
20 Application protection can have two states: a "high" state denotes out-of-proc and a "low"
21 state denotes in-proc. If enable debugger is set to "true," a script exception will result in
22 launching a debugger; otherwise, the exception will be logged and the synchronization will
23 continue. The complete exemplary format for this XML element is:


```

1      <extension>
2          <assembly-name>DLL name (string)</assembly-name>
3          <application-protection> low | high </application-protection>
4          <enable-debugger> true | false </enable-debugger>
5          <timeout> integer value </timeout>
6      </extension>

```

The <timeout> tag referred to above contains an integer specifying the number of seconds for the timeout. If set to 0, the timeout is disabled.

The password-change-history-size element specifies the number of the password management operations that can be saved in the metadirectory database 116. In one exemplary implementation, the default value is 24.

The <ma-data> XML element

An exemplary high level overview of the <ma-data> XML format is as follows:

```

13      <ma-data>
14          <format-version>1</format-version>
15          Naming information
16          Versioning information
17          Generic MA rule configuration
18          Controller configuration
19          Password sync configuration
20          UI configuration
21          Private configuration
22          Encrypted attribute configuration
23          Partition configuration
24          Run Profile configuration
25      </ma-data>

```

The <format-version> element has the same meaning as described in the above <mv-data> section. The remainder of the sub-elements are described in the following sections.

Naming Information

1 In the above format, the naming information refers to a grouping of elements that
2 provide the highest level information about the MA. In one exemplary implementation, all
3 elements in this grouping should be specified to the DCOM interface when an MA is created.

4 The following excerpt provides an example of the naming information.

```
5 <id>{3F5AA741-626E-483F-BB2D-EE0F5E73CE02}</id>  
6 <name>Ad Shadow</name>  
7 <category>AD</category>
```

8 The id element refers to a GUID that uniquely defines the MA in the metadirectory
9 system. It should be provided to the production system 106 on all calls involving creation or
10 modification of an MA. Once the MA is created this id never changes. Some considerations
11 applicable to the naming information are as follows. (1) When an MA is exported via an
12 “Export Management Agent” or “Export Server Configuration” processes, a GUID
13 corresponding to the MA is saved to the configuration file. (2) When a new MA is created
14 using a “Create” process provided by the configuration logic 142, the configuration logic 142
15 generates a new GUID and includes this new GUID when it sends the XML to the
16 metadirectory system through DCOM. (3) When a new MA is created using an “Import
17 Management Agent” process provided by the configuration logic 142, the configuration logic
18 142 generates a new GUID and uses this new GUID instead of whatever GUID may be in the
19 exported configuration file when the XML is sent to the metadirectory system. This allows
20 the exported MA configurations to be used as MA templates. (4) When a new MA is created
21 as part of an “Update MA From File” process or the “Import Server Configuration” process,
22 the GUID in the export file is passed to the metadirectory system. This allows the production
23 system 106 to update the existing design of the MA.
24
25

1 The “name” element refers to a non-empty string that provides the UI display name of
2 an MA in the metadirectory system. The metadirectory system forces this string to be unique.
3 The metadirectory system also places restrictions on the characters appearing in the name and
4 the length of the name. This is because the metadirectory system uses this name as the name
5 of a file system directory on the production system 106, and therefore it should meet certain
6 requirements in connection therewith. In one exemplary implementation, the length limit is
7 80 characters. The name can be modified by the user, and if so, will be included in the MA
8 XML on modify calls. If it is not being modified, it does not need to be included in the XML
9 on modification calls.

10 The category information refers to “MA type” as shown by the user interface
11 functionality of the metadirectory system. In one implementation, this type cannot be changed
12 once the MA has been created. In one exemplary implementation, supported types include:
13 LDAP types (e.g., AD, ADAM, AD GAL, iPlanet, Exchange, Exchange GAL, eDirectory,
14 etc.); File types (e.g., FIXED, DELIMITED, AVP, LDIF, DSML, etc.); and various other
15 types (e.g., MSSQL, Oracle, NT, Notes, etc.).

17 *Versioning Information*

18 The versioning information refers to a grouping of elements that provides versioning
19 information regarding the MA design. All elements in this grouping are read-only and are
20 returned by the production system 106 for informational purposes. An example of the
21 versioning information is listed below:

```
22           <creation-time>2002-07-23 17:12:23.699</creation-time>  
23           <last-modification-time>2002-07-23 19:21:17.699</last-  
24           modification-time>  
25           <version>5</version>
```

1 In this excerpt, the element creation-time refers to the time (e.g., in GMT) when the
2 MA was created on the metadirectory system.

3 The last-modification-time refers to the time (e.g., in GMT) when the design of the
4 MA was last modified on the metadirectory system.

5 The version information indicates the version of the MA configuration. Higher
6 numbers indicate later versions of the MA's configuration. When the configuration logic 142
7 updates an MA, the old version number that the edit is based on is passed in. If this number is
8 less than the current version stored in the metadirectory system database 116, the modification
9 will fail. This behavior is designed to prevent multiple users who may be editing the same
10 MA from negatively impacting each other.

11 *Generic MA Rule Configuration Information*

12 The generic MA rule configuration information refers to a grouping of elements that
13 convey the MA rule configuration that the user has configured for the MA in generic MA
14 configuration pages. It also includes the schema and attribute inclusion which may be
15 defaulted or obtained from the MA depending on the type of MA. The following excerpt
16 provides an example of how the generic MA rule configuration information would appear if
17 the user did not do any configuration in the generic MA configuration pages.
18
19
20

```
21 <schema>  
22 . . .  
23 </schema>  
24 <attribute-inclusion>  
25 <attribute>description</attribute>  
26 <attribute>displayname</attribute>  
27 <attribute>givenname</attribute>  
28 <attribute>manager</attribute>  
29 <attribute>member</attribute>  
30 <attribute>samaccountname</attribute>  
31 <attribute>sn</attribute>
```

```

1      </attribute-inclusion>
2      <stay-disconnector />
3      <join />
4      <projection />
5      <export-attribute-flow />
6      <provisioning-cleanup type="declared">
7          <action>make-explicit-disconnector</action>
8      </provisioning-cleanup>
9      <extension>
10         <assembly-name>IFMA.dll</assembly-name>
11         <application-protection>low</application-protection>
12     </extension>

```

The schema element referred to in the above-identified excerpt provides a description of the MA schema in DSML format. All attributes referred to by the elements which follow (attribute-inclusion, stay-disconnector, etc.) are defined in the schema. This schema is built up according to the following exemplary rules depending on the type of CD.

The following rules apply to LDAP types. (1) For AD and AD/AM types, the schema is discovered dynamically by the MA from the AD forest. The MA formats that schema into DSML (this formatting process can include special case logic). The configuration logic 142 queries the MA for this schema and includes an indication in the XML when the MA is imported. (2) For IPLANET types, the schema is discovered dynamically by the MA from the IPLANET server. The MA formats that schema into DSML (again, this formatting process can include special case logic). In the case of IPLANET 4.0, the configuration logic 142 will post-decorate the schema from the MA, marking the attributes involved in the anchor construction as immutable. (3) For EXCHANGE 5.5 and EXCHANGE 5.5. GAL types, the schema is discovered dynamically by the MA from the Exchange server. The MA formats that schema into DSML (again, this formatting process includes some special case logic). (4) For eDirectory types, the schema is discovered dynamically by the MA from the eDirectory

server and the MA formats that schema into DSML (again this formatting process includes some special case logic).

The following rules apply to File types. For all file types, the configuration logic 142 generates the DSML schema based on discovery of the sample file data and annotation the user enters using a wizard. Attributes that make up the anchor are declared as immutable. For FIXED, DELIMITED, and AVP formats, attributes that are specified as the hierarchical DN, change type, or object class will not be included in the schema unless they are also declared to be part of the overall anchor or a per object type anchor.

The following rules apply to so-called other types. (1) For MSSQL and ORACLE types, the MA reports the underlying database schema (in a private XML non-DSML format) to the configuration logic 142. The configuration logic 142 generates the DSML representation based on user selection. This is because the user can select which attributes form the primary key (and thus the user needs to mark these attributes as immutable). Also, the user can indicate that certain attributes are reference attributes. (2) For NT types, the MA reports a fixed schema to the configuration logic 142 that models the NT 4.0 SAM database structure. (3) For Notes types, forms and subforms are used in Notes for the schema information. From version 5.0, Notes supports LDAP v3. The Notes system generates a schema50.nsf file to map the Notes-specific schema to an LDAP schema. The schema50.nsf contains all the schema information that is needed. Since it is an .nsf file, the same method used for import can be used to retrieve the information from the file. (Basically, this application reads each of the Notes in the .nsf file and gets all the field information). An extra step converts the output to DSML format.

The attributes-inclusion element lists attributes from the CD that the MA should import. Only attributes that appear in this list can be part of any of the sub-elements which

follow (e.g., stay-disconnector, join, project, import attribute flow, export attribute flow, etc).

This list applies to all partitions in the MA. If this section is missing or empty, deltas will only be imported with DN, anchor, and modification type.

The stay-disconnector element specifies whether a CS entry should stay as a disconnector in CS, or get passed in the metadirectory system sync cycle. Exemplary functionality and formats for this element are described in the appendix section of this disclosure.

The join element governs how the synchronization engine should search the MV for CS objects to join. Exemplary functionality and formats for this element are described in the appendix section of this disclosure.

The project element governs how (if any) CS objects are projected as new entries in the MV. Exemplary functionality and formats for this element are described in the appendix section of this disclosure.

The export-attribute-flow element governs how values of attributes of MV objects should be flown back to connected CS objects. Exemplary functionality and formats for this element are described in the appendix section of this disclosure.

The provisioning-cleanup rule or extension is called for a CS object when either (1) the MV provisioning script disconnects that object or (2) the MV object (CS object) it is joined to is deleted. The default behavior is to make an explicit disconnector based on the CS object. This rule will not be called if the object is disconnected by the Account Joiner or a delete on this object is imported from the CD. An exemplary complete format for this XML sub-element is:

```

1      <provisioning-cleanup type="declared | scripted">
2          <action>
3              delete-object |
4              make-normal-disconnector |
5              make-explicit-disconnector
6          </action>
7      </provisioning-cleanup>

```

The extension element appears when one or more of the above sub-elements requires a .NET extension DLL for evaluation. It identifies the name of the assembly to use and indicates whether to run the extension within the metadirectory system process (application-protection = low) or outside the metadirectory system process (application-protection = high).

A complete exemplary format for this XML sub-element is:

```

11     <extension>
12         <assembly-name>DLL name (string)</assembly-name>
13         <application-protection>high|low</application-protection>
14     </extension>

```

Controller Configuration Information

The controller configuration information controls how the controller should run the MA. An exemplary XML structure for this element is as follows:

```

19     <controller-configuration>
20         <application-protection>low</application-protection>
21         <impersonation>
22             <domain>ntdev</domain>
23             <user>maxb</user>
24             <password>mypassword </password>
25         </impersonation>
26     </controller-configuration>

```


1 The application-protection element in the above XML structure indicates whether the
2 controller should run in a separate process (“high”) or in the same process (“low”) as the
3 metadirectory NT service.

4 The impersonation element is present only if the controller should impersonate
5 another identity whenever it makes calls into the MA DLL. This feature is a general controller
6 feature that has been added to make it possible to run the DBMA with the SQLOLEDB or
7 ORACLE provider using Windows Authentication as a different user identity than the
8 metadirectory service.

9 More specifically, if this element is present, the <domain> and <user> sub-elements
10 should both be present (omission of the <password> element indicates that there is no
11 password). If no impersonation context needs to be configured, the entire <impersonation>
12 context is omitted. When the <controller-configuration> element is fetched from the
13 metadirectory service, the password element is not returned (for security reasons).
14

15 *Password Sync Configuration Information*

16 The password sync configuration information controls whether the MA calls of “set
17 password” and “change password” can be used for this MA.

18 <password-sync-allowed>1|0</password-sync-allowed>

19
20 If the inner value is 1, the “set password” and “change password” calls will be allowed
21 (subject to whether this is supported by this MA type and normal security). If the inner value
22 is 0, the calls will fail accompanied by a diagnostic error. The default value is 0.

23 *UI Configuration Information*

24
25

The UI configuration information refers to a grouping of sub-elements that saves information that is used by the UI. This information is ignored by both the production system 106 server and the MA DLL. An example of the UI configuration element follows:

```
<description>My description</description>
<ma-ui-settings>
  <account-joiner-queries>
    . . .
  </account-joiner-queries>
</ma-ui-settings>
```

In this example, the description element refers to a text description used to record any information about an MA that a user may wish to record. This description is shown on a first page of the MA property pages.

The ma-ui-settings element is used by the UI to describe per-MA settings made by the user. For instance, a setting can be recorded for an account joiner page. For reference, the inner XML contains the following sub-elements:

“Attributes” records the columns configured for the upper grid of CS objects and the lower grid of MV objects.

```
<attributes>
  <cs>
    <attribute name="DN" header="DN" size="100" />
    <attribute name="objectType" header="objectType" size="100" />
    <attribute name="displayname" header="displayname" size="100" />
  </cs>
  <mv>
    <attribute name="displayName" header="displayName" size="100" />
  </mv>
</attributes>
```

“Filters” records the filter used for searching for the MV objects which match the selected CS object.

```
<filters max_mv_search_results="">
  <filter name="Filter 1" collation="SQL_Latin1_General_CP1_CI_AS"
searchscope="person">
    <element cdattribute="displayname" mvattribute="displayName"
mvtextflag="true" elementoperator="exact" />
  </filter>
</filters>
```

The reason that this information is stored with the MA instead of in a file on the local client machine is because this strategy allows the administrator to set up the display columns and filter criteria so that these can be used by persons using the account joiner screen.

In contrast, the MV and CS search settings are stored per machine. The users of MV and CS search are likely individual users with administrator privilege who each have their own personal search preferences.

Private Configuration Information

The private configuration information refers to the private configuration of the MA, as specified by the <private-configuration> element. Within this element, the format is MA-specific and is generally information that is shared between the MA UI and MA DLL.

The following examples apply to LDAP types. To begin with, the following provides an example of AD private configuration:

```
<private-configuration>
  <adma-configuration>
    <forest-guid>...</forest-guid>
    <forest-name>mms-sh1-corp.nttest.microsoft.com</forest-name>
    <forest-login-domain>mms-sh1-corp</forest-login-domain>
    <forest-login-user>administrator</forest-login-user>
  </adma-configuration>
</private-configuration>
```

The following provides an example of AD/AM private configuration:

```

1      <private-configuration>
2      <adma-configuration>
3      <forest-name>mms-sh1-corp.nttest.microsoft.com</forest-name>
4      <forest-port>389</forest-port>
5      <forest-login-domain>mms-sh1-corp</forest-login-domain>
6      <forest-login-user>administrator</forest-login-user>
7      <sign-and-seal>1|0</sign-and-seal>
8      <ssl-bind>1|0</ssl-bind>
9      </adma-configuration>
10     </private-configuration>

```

The following provides an example for iPlanet 5.x and iPlanet 4.x private configuration:

```

11     <private-configuration>
12     <ipma-configuration>
13     <default-server>mms-ip5-bvt</default-server>
14     <default-login-user>cn=Directory Manager</default-login-user>
15     <default-port>389</default-port>
16     <default-ssl-bind>0</default-ssl-bind>
17     <ui-data>
18     <session>{107D1AA1-49C6-4AA0-BC59-CC0DAC930311}</session>
19     <server-type>SERVER_TYPE_IPLANET5</server-type>
20     <supportchangelog>1</supportchangelog>
21     </ui-data>
22     </ipma-configuration>
23     </private-configuration>
24
25     <private-configuration>
26     <ipma-configuration>
27     <default-server>nt4-riplanet</default-server>
28     <default-login-user>cn=Directory Manager</default-login-user>
29     <default-port>389</default-port>
30     <default-ssl-bind>0</default-ssl-bind>
31     <ui-data>
32     <session></session>
33     <server-type>SERVER_TYPE_IPLANET4</server-type>
34     <supportchangelog>1</supportchangelog>
35     </ui-data>
36     <anchor-attributes>
37     <anchor-attribute>
38     <name>cn</name>
39     <object-type>person</object-type>
40     </anchor-attribute>
41     </anchor-attributes>
42     </ipma-configuration>
43     </private-configuration>

```

The following provides an example of private configuration for EXCHANGE 5.5.

GAL:

```

1      <private-configuration>
2          <exma-configuration>
3              <default-server>default server name for OU, schema,
4              and server discovery</default-server>
5              <default-login-domain>domain</default-login-domain>
6              <default-login-user>user</default-login-user>
7          </exma-configuration>
8      </private-configuration>

```

The following provides an example of private configuration for eDirectory:

```

6      <private-configuration>
7          <edma-configuration>
8              <default-server>mms-edirectory3</default-server>
9              <default-login-user>cn=admin,o=mmstest</default-login-
10             user>
11              <default-ssl-bind>0</default-ssl-bind>
12              <default-port>389</default-port>
13          </edma-configuration>
14      </private-configuration>

```

The following examples apply to so-called other types. To begin with, the following provides an example of SQLOLEDB private configuration:

```

14      <private-configuration>
15          <oledbma-configuration>
16              <connection-info>
17                  <authentication>integrated</authentication>
18                  <provider>SQLOLEDB</provider>
19                  <server>...</server>
20                  <databasename>...</databasename>
21                  <tablename>...</tablename>
22                  <delta-tablename>...</delta-tablename>
23              </connection-info>
24              <mms-info>
25                  <column-info>
26                      <column>
27                          <name>id</name>
28                          <data-type>DBTYPE_STR</data-type>
29                          <length>11</length>
30                          <isnullable>0</isnullable>
31                          <isreadonly>0</isreadonly>
32                          <mms-type>String</mms-type>
33                      </column>
34                      <column>
35                          <name>manager</name>
36                          <data-type>DBTYPE_STR</data-type>
37                          <length>40</length>
38                          <isnullable>0</isnullable>
39                          <isreadonly>0</isreadonly>
40                          <mms-type dn='1'>String</mms-type>

```

```

1      </column>
2      . . .
3      </column-info>
4      <delta-info>
5          <extra-columns> ... </extra-columns>
6          <change-column> ... </change-column>
7          <add> ... </add>
8          <update> ... </update>
9          <delete> ... </delete>
10         </delta-info>
11     <anchor>
12         <attribute>au_id</attribute>
13     </anchor>
14     <object-type>person</object-type>
15     </mms-info>
16 </oledbma-configuration>
17 </private-configuration>

```

In the above example, note that “delta-tablename” is only included when deltas are configured. When deltas are configured, the “delta-info” element should also be included. The “extra-columns” element is only used by the configuration logic UI; it indicates the columns not in the main table that can be displayed in the change column picker.

The following provides an example of ORACLE private configuration:

```

14 <private-configuration>
15 <oledbma-configuration>
16 <connection-info>
17     <authentication>integrated</authentication>
18     <provider>MSDAORA</provider>
19     <datasource>....</datasource>
20     <tablename>....</tablename>
21     <delta-tablename>....</delta-tablename>
22 </connection-info>
23 <mms-info>
24 <column-info>
25     <column>
26         <name> id</name>
27         <data-type>DBTYPE_STR</data-type>
28         <length>11</length>
29         <isnullable>0</isnullable>
30         <isreadonly>0</isreadonly>
31         <mms-type>String</mms-type>
32     </column>
33     <column>
34         <name>manager</name>
35         <data-type>DBTYPE_STR</data-type>
36         <length>40</length>
37         <isnullable>0</isnullable>
38         <isreadonly>0</isreadonly>
39         <mms-type>dn = '1'>String</mms-type>

```

```

1      </column>
2      . . .
3      </column-info>
4      <delta-info>
5          <extra-columns> ... </extra-columns>
6          <change-column> ... </change-column>
7          <add> ... </add>
8          <update> ... </update>
9          <delete> ... </delete>
10     </delta-info>
11     <anchor>
12         <attribute>au_id</attribute>
13     </anchor>
14     <object-type>person</object-type>
15     </mms-info>
16 </oledbma-configuration>
17 </private-configuration>

```

The configuration format for ORACLE is very similar to SQLOLEDB except for the connection information.

The following provides an example of NT private configuration:

```

12 <private-configuration>
13   <ntma-configuration>
14     <domain>ntma1</domain>
15     <login-user>administrator</login-user>
16     <login-domain>ntma1</login-domain>
17   </ntma-configuration>
18 </private-configuration>

```

The following provides an example of NOTES private configuration:

```

17 <private-configuration>
18   <lnma-configuration>
19     <server>mms-domino4/Redmond</server>
20     <userid>C:\mmsbvt\Notes4Admin.id</userid>
21     <cookie>PL1/ABJtJQg=</cookie>
22     <ou-list>
23       <item>
24         <nab>names.nsf</nab>
25         <ou>O=Redmond</ou>
26         <certifier-path>C:\mmsbvt\Notes4RCert.id</certifier-
27 path>
28       </item>
29     </ou-list>
30   </lnma-configuration>
31 </private-configuration>

```

Encrypted Attributed Configuration Information

The encrypted attribute configuration information servers two purposes: (1) It is used by the configuration logic UI to convey password information from the MA UI to the metadirectory system when creating or updating MA credential information; (2) It is used by the metadirectory system to pass the MA DLL credentials information at the start of each run.

The basic exemplary format of this information is:

```
<encrypted-attributes>
  <attribute name="foo" partition="bar">value</attribute>
  <attribute name="foo" partition="bar">value</attribute>
  ...
</encrypted-attributes>
```

The production system server implements the semantics when the UI submits a <encrypted-attributes> element. In connection therewith, each <attribute> element with a name/partition value combination which is different from what is currently stored for the MA and has a non-empty value is added to the list of <attribute> elements stored for the MA. Further, if an <attribute> element matches an existing element by name and partition and the value is nonempty, then the existing element's value is replaced with the one submitted. Further, if an <attribute> element matches an existing element by name and partition but its value is empty, then the existing element is removed from the list of encrypted attributes stored for the MA.

The meanings of the "name" and "partition" attributes are MA-specific, and indeed, the partition attribute is not even required. Generally, "name" represents the name of the

1 attribute that needs to be encrypted and the partition is the name of the partition that this
2 attribute is associated with.

3 For AD LDAP types, one <attribute> element with name = “password” and no
4 partition attribute is stored to record the credentials information for the forest.

5 For AD/AM LDAP types, one <attribute> element with name = “password” and no
6 partition attribute is stored to record the credentials information for the production system
7 server.

8 For SQLOLEDB and ORACLE (other types), when using SQL or ORACLE security
9 mode, there will be one <attribute> element with name = “password” and no partition
10 attribute. This represents the database password of the account sent to the production system
11 server.

12 *Partition Configuration Information*

13
14 The following section describes the “partitions” of the MA. MA’s consist of one or
15 more partitions, each partition having a specified container/object type filter criteria associated
16 with it. By definition, the filter criteria of different partitions are required to be disjoint.

17 The overall exemplary format for this element is:

18
19
20 <ma-partition-data>
21 <partition> . . .</partition>
22 <partition> . . .</partition>
23 . . .
24 </ma-partition-data>
25

23 The format for storing the configuration of a partition mimics the storage of the
24 configuration of an MA on a whole in some ways:
25

1 <partition>

2 *Naming information*

3 *Versioning information*

4 *Partition details*

5 </partition>

6
7 The above-identified partition naming information refers to a grouping of sub-
8 elements that describes the highest level information regarding the partition. All sub-elements
9 in this grouping should be specified when the partition is created through DCOM. The
10 following shows how the naming information appears according to one implementation:

11
12 <id>{3F5AA741-626E-483F-BB2D-EE0F5E73CE02}</id>
13 <name>DC=africa,DC=mms-shl-
14 corp,DC=nttest,DC=microsoft,DC=com</name>

15 In this excerpt, the id refers to a GUID that uniquely defines the partition in the
16 system. It should be given to the production system server on all calls involving creation or
17 modification of an MA partition. Once a partition is created, this id does not change. The
18 following additional considerations apply to this topic: (1) When an MA is exported via the
19 “Export To File” or “Save Server Configuration” processes, the id for each partition is saved
20 to the file. (2) When a new MA is created using the “Create” process from the configuration
21 logic UI, the metadirectory system administrative client generates a new GUID and includes it
22 when it sends the XML to the metadirectory system through a DCOM call. (3) When a new
23 MA is created using the “Import Management Agent” process from the configuration logic
24 UI, the metadirectory system administrative client generates new GUID’s for each of the
25

1 partitions and uses these instead of the GUID's in the export file when it sends the XML to the
2 metadirectory system. The reason for this is to enable the exported MA configurations to be
3 used as MA templates. (4) When a new MA is created as part of the "Update MA from File"
4 or the "Import Server Configuration" processes, the GUID in the export file is passed to the
5 metadirectory system. This allows the server to match up the partitions in the file with those
6 in the MA on the target production system.

7 The name element refers to a non-empty string that the configuration logic UI displays
8 for the partition. In one exemplary implementation, the length limit can be 400 characters and
9 characters '<', '>', '&', '\\', '\"', and ']' are disallowed in the name. The configuration logic
10 UI chooses the name according to the following rules:

11 The following rules apply to LDAP types. For AD or AD/AM, a partition
12 corresponds to a DNC or NDNC. The name is the DN of the DNC or NDNC in AD. For
13 IPLANET, a partition corresponds to an iPlanet server partition. The name is the DN of the
14 partition on the server. For EXCHANGE 5.5, a partition corresponds to an Exchange "site."
15 The name is the X.500 DN of the OU. For EXCHANGE 5.5. GAL, this MA has exactly one
16 partition named "default." For eDirectory, this MA has exactly one partition named "default."
17

18 As to all File types, most users will have only one partition which is named "default,"
19 but users can create additional partitions for different object types.

20 For all other types, these MA's each have exactly one partition named "default."

21 The partition version information refers to a grouping of sub-elements that provides
22 versioning information about the partition configuration. All sub-elements in this grouping
23 are read-only and are returned by the server for informational purposes. The following
24 provides an example of the structure of such information:
25

```
1      <creation-time>2002-07-23 17:12:23.699</creation-time>
2      <last-modification-time>2002-07-23 19:21:17.699</last-modification-
3      time>
4      <version>5</version>
```

5 The creation-time element refers to the time (in GMT) when the partition was created
6 on the metadirectory system. The last-modification-time element refers to the time (in GMT)
7 when the partition configuration was last modified on the metadirectory system. The version
8 element indicates the version of the partition configuration. Higher numbers indicate later
9 versions of the configuration. When a partition is updated, the old version number the edit is
10 based on is passed in. If this number is less than the current version stored in the
11 metadirectory system database 116, the modification will fail.

12 The partition details information refers to a grouping of elements that specifies the
13 actual configuration of the partition. An exemplary structure for this element is as follows:

```
14
15      <selected>0</selected>
16      <filter>
17          <object-classes>
18              <object-class>contact</object-class>
19              <object-class>container</object-class>
20              <object-class>group</object-class>
21              <object-class>user</object-class>
22          </object-classes>
23          <containers>
24              <exclusions/>
25              <inclusions>
26                  <inclusion>DC=africa,DC=mms-sh1-
27                      corp,DC=nttest,DC=microsoft,DC=com</inclusion>
28              </inclusions>
29          </containers>
30      </filter>
31      <custom-data>
32          ...
33      </custom-data>
```

1 In the above structure, the selected element provides a bit value (1 or 0) indicating
2 whether the partition has been selected by the user in the configuration logic UI for
3 configuration. The following breakdown indicates MA specific information about this bit:

4 For AD, AD/AM, IPLANET, and Exchange 5.5 LDAP types, this bit corresponds to
5 whether the partition has been “checked” in the configuration logic UI.

6 For EXCHANGE 5.5. GAL LDAP types, the single partition is marked selected.

7 For all file types, all partitions are marked as selected.

8 For all other types, the single partition is marked selected.

9 As can seen from the above breakdown, this bit is really only of interest in the case of
10 LDAP MA’s such as AD, iPlanet, and Exchange 5.5, which have multiple partitions which the
11 user can either configure or leave unconfigured. Runs against unconfigured (that is,
12 unselected) partitions are expected to fail, and the configuration logic UI should not allow
13 configuration of the partition (or creating run profiles) with unselected partitions.
14

15 The filter element is used by the MA to determine which objects to import into the CS.
16 The metadirectory system architecture allows MA’s to filter on both object types and
17 containers (DN). Consequently, there are two elements to this XML format: “object-classes”
18 and “containers.”

19 In the “object-classes” section, a user can specify what object type to participate in the
20 synchronization process (inclusion). In the “containers” section, the user can specify which
21 container to include as well as which to exclude (both inclusion and exclusion). During
22 filtering, for each DN, the inclusion/exclusion list is searched to find the longest ancestor. If
23 the longest ancestor is included, the DN is included, if the longest ancestor is excluded, the
24 DN is excluded.
25

1 The following breakdown provides the MA-specific semantics related to filtering for
2 LDAP types (e.g., for AD, AD/AM, IPLANET, Exchange 5.5, EXCHANGE 5.5. GAL, and
3 eDirectory). Regarding object type inclusion, these MA's support a single object type
4 inclusion filter that applies to all partitions. Even though the object type filter is specified for
5 each partition, a properly configured MA of this type will have the same object type
6 configuration for each of its partitions. Regarding container filtering, container filtering is per
7 partition. The users can use the container picker to select the desired containers to import
8 from. The MA-specific UI generates inclusion/exclusion rules corresponding to the container
9 picker selections. The MA adds in exclusion filter conditions to ensure there is no overlap
10 between parent and child domains.

11 For all file types, there is no container filtering support. Partitions are defined exactly
12 by what object types they contain.

13 The following considerations apply to so-called other types. For MSSQL and
14 ORACLE, there is no filtering support. If users want a filtered view of the table they are
15 expected to define a view and configure their MA to operate off that view. For NT 4.0, there
16 is no container filtering support, but users can filter on object classes. For NOTES, there is no
17 container filtering support, but users can filter on object classes.

18 The custom-data element refers to an MA-specific XML format to record additional
19 information about the partition.
20

21 The following excerpt shows custom data for an AD partition:
22

```
23  
24       <custom-data>  
25        <adma-partition-data>  
      <dn>DC=africa,DC=mms-sh1-  
      corp,DC=nttest,DC=microsoft,DC=com</dn>
```

```

1      <name>africa.mms-sh1-corp.nttest.microsoft.com</name>
2      <guid>{BA84A62C-504E-44B9-9FFE-CF52028B4A36}</guid>
3      <is-domain>1</is-domain>
4      <sign-and-seal>1</sign-and-seal>
5      <preferred-dcs>
6          <preferred-dc> ... </preferred-dc>
7          <preferred-dc> ... </preferred-dc>
8          . . .
9      </preferred-dcs>
10     <dc-failover>1</dc-failover>
11 </adma-partition-data>
12 </custom-data>

```

In this example, “dn” refers to the DN of AD naming context, “name” refers to the NetBIOS name of the naming context, “GUID” refers to the AD’s GUID (unchanging id) for the naming context, “is-domain” indicates whether it is a DNC or NDNC, “sign-and-seal” indicates whether the user has checked the sign-and-seal option in the UI, “preferred-dcs” is the list of preferred DC’s to use when connecting to this naming context in priority order, “dc-failover” indicates whether the user wants the MA to failover to DC’s not specified in the preferred DC list, “last-dc” is the last DC used for a run on this partition (which is only present if MA has been run on this partition), “cookie” refers to the current watermark from DirSync from last import run (which is only present if MA has been run on this partition), “login-domain” refers to a domain that, if the customer has configured specific credentials for this partition, then this gives the domain, “login-user” refers to an account that, if the customer has configured specific credentials for this partition, then this gives the account.

The following provides an example of the custom data for an IPLANET partition:

```

21     <custom-data>
22         <ipma-partition-data>
23             <dn>o=bvts</dn>
24             <port>389</port>
25             <ssl-bind>0</ssl-bind>
26             <last-change-number>10315</last-change-number>
27         </ipma-partition-data>
28     </custom-data>

```

The following example provides custom data for EXCHANGE 5.5. GAL:

```
<custom-data>
  <exma-partition-data>
    <dn>partition DN</dn>
    <last-server>server</last-server>
    <preferred-servers>
      <server>preferred server</server>
      ...
    </preferred-servers>
    <available-servers>
      <server>available server</server>
      ...
    </available-servers>
    <server-failover>1 or 0</server-failover>
    <use-ssl>1 or 0</use-ssl>
    <highest-usn>primary watermark value</highest-usn>
    <highest-timestamp>secondary watermark value</highest-
timestamp>
  </exma-partition-data>
</custom-data>
```

The following example provides custom data for AD/AM:

```
<custom-data>
  <adma-partition-data>
    <dn>CN=ADAM-BVTs</dn>
    <name>CN=ADAM-BVTs</name>
    <guid>{F08F99E2-B823-4AB5-9725-57F9949C251E}</guid>
    <sign-and-seal>1</sign-and-seal>
    <is-domain>1</is-domain>
    <dc-failover>1</dc-failover>
  </adma-partition-data>
</custom-data>
```

The allowed-operations element refers to a completely internal read-only element that is used by the production system server to convey information to the configuration logic UI regarding what MA runs should bring up warnings or be disallowed. It is never emitted into files that customers can view. It is a DWORD with values:

BFALLOWED_DELTA_IMPORT	= BIT(0),
BFALLOWED_DELTA_NO_MA_CONFIG_CHANGED	= BIT(1),
BFALLOWED_DELTA_NO_MV_CONFIG_CHANGED	= BIT(2),
BFALLOWED_DELTA_NO_MV_DLL_CHANGED	= BIT(3),
BFALLOWED_DELTA_NO_MA_DLL_CHANGED	= BIT(4),
BFALLOWED_SUPPRESS_WARNINGS	= BIT(29),
BFALLOWED_NO_OPERATION_RUN	= BIT(30),

Run Profile Configuration Information

The run profile configuration information describes the “run profiles” defined for the MA. The overall format for this element is:

```
<ma-run-data>
  <run-configuration>...</run-configuration>
  <run-configuration>...</run-configuration>
  . . .
</ma-run-data>
```

An exemplary format for the <run-configuration> element can be found in the appendix of this disclosure.

C. Exemplary Techniques and Systems for Configuring a Metadirectory System

Having described an exemplary implementation of a multidirectory system in Section B, the following section presents details regarding a process for configuring such a system. The specific information imparted herein is exemplary. Other processes can be developed based on the principles described herein for other kinds of directory management systems that differ from the process described below in various respects.

C.1. Overview of Export/Import Processes

To begin with, Fig. 8 shows a general method 800 for moving configuration files from the lab production environment 102 to the production environment 104. Reference is made to the individual steps in Fig. 8 in tandem with the features described in Fig. 1.

In step 802, a user (such as user 132 or 140) creates configuration information 136 that may comprise one or more configuration files. More specifically, this act of creation may constitute the generation of an MA that prompts the generation of an entirely new MA file.

1 Alternatively, this act of creation may constitute the modification of an existing MA file that
2 prompts the modification of an existing MA. Still alternatively, this act of creation may
3 constitute the creation of an entire suite of MA files and an associated MV file for configuring
4 the entire production system 106 (or multiple parts thereof).

5 Whatever the case, in step 804, the user exports the configuration information 136 to
6 the storage location 138. For instance, the user can use file management UI functionality to
7 identify a location in a directory that stores the configuration information 136. As stated, this
8 storage 138 location can be physically associated with the lab environment 104, the
9 production environment 102, or some other location.

10 In step 806, a user associated with the production environment 102 imports the
11 configuration information 136 stored at the storage location 138 into the production system
12 106. The production system 106 thus assumes the role of a “target” system by receiving the
13 configuration information, and is alternatively referred to in this section as the target
14 production system 106. Step 806 involves different processes depending on the nature of the
15 configuration task specified in the configuration information 136. In a first case (808), the
16 configuration logic 142 employs the process shown in Fig. 10 to import a new MA. In a
17 second case (810), the configuration logic 142 employs the process shown in Fig. 11 to update
18 an existing MA. That is, in this case (810), the production system 106 already stores an MA
19 associated with the MA identified in the configuration information 136. The goal in this case
20 is to modify or amend the existing MA in accordance with the information contained in the
21 configuration information 136 (based on a comparison of the configuration of the existing MA
22 and the configuration information 136). In this context, the existing MA in the production
23 system 106 assumes the role of a “target” MA. Finally, in a third case (812), the configuration
24
25

logic 142 employs the process shown in Fig. 12 to import configuration files that define the configuration of the entire production system 106. Such a configuration task can involve adding one or more new MA's, as well as updating one or more existing MA's, and therefore, this process draws from the first and second processes (808, 810) discussed above. This is illustrated in Fig. 8 by showing flow boxes labeled 808 and 810 within flow box 812.

The following sections describe the export and import processes in greater detail.

C.2. Export Processes

Exporting an MA

A user (e.g., user 132 or 140) can use the user interface functionality, a command line utility, or some other functionality to save a created MA file to the storage location 138. In one implementation, the import process does not involve the transfer of any extension files referenced in the created MA file, such as DLLs. The user should therefore make special provisions to transfer these files. In other implementations, the export process can incorporate functionality for automatically transferring such extension files.

In one exemplary implementation, the lab system 108 produces an output MA file having the following form:

```
<export-ma server='name of server' export-date='date'>
<!--WARNING>
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!
!! The contents of this file should not be edited.
!! Any such modifications to this file may result in errors during
!! import.
!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
</WARNING -->

<ma-data>
. . .
</ma-data>
```

```

1      <mv-data>
2      <import-attribute-flow>
3      . . .
4      </import-attribute-flow>
5      </mv-data>
6      </export-ma>

```

The <ma-data> element and the <import-attribute-flow> element have formats described in the previous section. In one implementation, the configuration logic 142 generates the outer elements of the file format described above. Other aspects of the production system 106 generate the inner elements of the file format, namely, the <ma-data> and <mv-data> and elements.

Exporting a System Configuration

The user can also create and export information that specifies the configuration of the entire production system 106, which may have multiple MA's associated therewith. As in the case of a single MA file, the user can use the user interface functionality, a command line utility, or some other functionality to export the server configuration information 136 to the storage location 138. In one implementation, the user should independently transfer any extension files or functionality associated with the server configuration information 136.

The server configuration information 136 can include a suite of server configuration files, including a file called "MV.XML." The MV.XML file specifies the server-wide metaverse configuration of the production system 106. The following excerpt provides an exemplary high-level listing of an MV.XML file:

```

22      <saved-mv-configuration server='MAXBDESK2' export-date='2002-07-30
23      15:00:39.000'>
24      <!--WARNING>
25      !!
26      !! The contents of this file should not be edited.
27      !! Any such modifications to this file may result in errors during
28      !! import.

```

```

1      !!
2      !!
3      </WARNING-->
4
5      <mv-data>
6      <format-version>1</format-version>
7      <version>2</version>
8      <schema>
9      . . .
10     </schema>
11     <import-attribute-flow>
12     . . .
13     </import-attribute-flow>
14 </mv-data>
15 </saved-mv-configurations>
16
17
18
19
20
21
22
23
24
25

```

Again, Section B above describes the exemplary composition of the elements within the body the MV.XML file.

In addition to the MV.XML file, the server configuration information 136 can include multiple MA files. These files are respectively associated with each of the MA's in the production environment 102. These files are identified as MA.XML files. The export process generates the name of these files based on the id's of the respective MA's. The following excerpt identifies an exemplary format for an MA.XML file generated upon the export of the server configuration information 136.

```

17     <savd-ma-configuration server='name of server' export-date='date'>
18
19     <!--WARNING>
20     !!
21     !! The contents of this file should not be edited.
22     !! Any such modifications to this file may result in errors during
23     !! import.
24     !!
25     !!
26     </WARNING-->
27
28     <ma-data>
29     ...
30     </ma-data>
31 </ saved-ma-configuration >
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
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63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99

```

1 Earlier sections describe the exemplary format of the <ma-data> element. Note that, unlike
2 the format used for exporting a single MA file, the above-listed format omits an “import-
3 attribute-flow” element.

4 In one implementation, the configuration logic 142 generates the outer elements of the
5 file format described above. Other aspects of the production system 106 generate the inner
6 elements of the file format, namely, the <ma-data> and <mv-data> elements.

7 **C.3. Import Processes**

8 **Importing an MA**

9
10 Fig. 9 describes a process 900 for creating a new MA using a file produced by
11 exporting an MA from the lab environment 104 (and, if appropriate, from any saved DLL
12 extensions associated with the file). The process 900 generally includes step 902 of
13 processing ma-data in the configuration file and step 904 of processing mv-data in the
14 configuration file.

15 The step 902 of processing ma-data includes multiple subprocesses to handle
16 individual parts of the ma-data. That is, as previously described, the ma-data includes at least
17 the following parts: naming information; versioning information; generic MA rule
18 configuration information; controller configuration information; password sync configuration
19 information; UI configuration information; private configuration information; encrypted
20 attribute configuration information; partition configuration information; and run profile
21 configuration information. Step 902 is expanded in the right side of Fig. 9 to yield box 902'
22 that shows processing associated with each of these parts. Each of these parts is described
23 below in turn.
24
25

1 Substep 906 involves processing naming information provided by the ma-data. As
2 explained in Section B, the naming information includes elements <id>, <name>, and
3 <category>. As to the <id> element, the configuration logic 142 generates a new GUID at the
4 time of import (thus ignoring the GUID in the configuration file). By ignoring the GUID in
5 the configuration file, the configuration logic 142 provides “create from template”
6 functionality. As to the <name> element, the configuration logic 142 uses the name provided
7 in the file as the name of the MA. If an MA with this name exists in the production system
8 106, then the configuration logic 142 will prompt the user to enter a new name. As to the
9 <category> element, the configuration logic 142 accepts the category identified in the
10 configuration file as the type of MA to be created.

11 Substep 908 involves processing versioning information provided in the ma-data. As
12 explained in Section B, the versioning information includes elements <creation-time>, <last-
13 modification-time>, and <version>. As to the <creation-time> element, the configuration
14 logic 142 ignores the time specified in the configuration file. The configuration logic 142 sets
15 this time to the time when the new MA is created. As to the <last-modification-time>, the
16 configuration logic 142 likewise ignores the time specified in the configuration file. The
17 configuration logic 142 initially sets this time to be the time when the new MA is created. As
18 to the <version> element, the configuration logic 142 ignores the version specified in the file.
19 The configuration logic 142 sets the version of the new MA to 1.
20

21 Substep 910 involves processing generic configuration information provided in the
22 ma-data. As explained in Section B, the generic configuration information includes a
23 <schema> element. The configuration logic 142 determines an “authoritative schema,” that is,
24 a schema that is saved with the MA, according to the following considerations. (1) For call-
25 based MA’s other than MSSQL and ORACLE MA’s, the configuration logic 142 will call the

1 MA's GetSchema method to get an authoritative schema. (2) For File MA's, the
2 configuration logic 142 takes the schema found in the file as authoritative. (3) For MSSQL
3 and ORACLE MA's, the configuration logic 142 calls the MA to get the schema in the CD
4 and compares it with the schema in the file. In this case, the configuration logic 142 builds the
5 schema from the CD, but if the same column appears in both the CD schema and the file
6 schema, then the configuration logic 142 applies the following logic: (a) if that column is
7 declared to be a "reference" in the file and has a type that permits it to be a reference attribute,
8 then the configuration logic 142 makes it a reference; and (b) if that column is part of the
9 primary key in the file, it will be part of the primary key in the final schema (and marked
10 immutable). The configuration logic 142 defines other rule elements according to the contents
11 of the configuration file. The configuration logic 142 will perform property page validation of
12 these settings against the contents of the authoritative schema and allow the user to correct any
13 mismatches.

14 Substep 912 involves processing controller configuration information provided in the
15 ma-data. The configuration logic 142 uses the controller configuration specified in the file. If
16 the file contains an impersonation element, the configuration logic 142 will bring up the
17 property pages to prompt the user to enter a password. If the file does not include an
18 impersonation element, the configuration logic 142 will assume that application protection is
19 "low" and that there is no impersonation.
20

21 Substep 914 involves processing UI configuration information provided in the
22 configuration file. For this piece of information, the configuration logic 142 uses the
23 <description> and <ma-ui-settings> present in the file.

24 Substep 916 involves processing private configuration information provided in the
25 configuration file. Generally the configuration logic 142 uses the private configuration

1 information specified in the configuration file. For IPLANET and the FILE MA types, which
2 allow per object anchor configuration, the configuration logic 142 will be run through a
3 property page validation routine. This routine ensures that the attributes in the anchor are
4 defined in the schema and that they are declared as immutable.

5 Substep 918 involves processing encrypted attribute configuration information. In one
6 implementation, this information is omitted from the configuration file.

7 Substep 920 involves processing of partition configuration information in the
8 configuration file. Generally, the configuration logic 142 handles partition information in an
9 MA-specific manner. For LDAP MA's, the following considerations apply to the processing
10 of the configuration file. (1) The configuration logic 142 discovers the actual partitions
11 present in the CD. These partitions will form the list of actual partitions in the final
12 configuration. The configuration logic 142 initially marks all of these CD partitions as
13 UNSELECTED. (2) First, in the case of an AD, the configuration logic 142 tries to
14 definitively match each SELECTED partition contained in the configuration file with a single
15 CD partition. In the case of AD, the configuration logic 142 performs this task using the AD
16 GUID of the partition. If this match occurs, the configuration logic 142 copies the information
17 from the file partition to the CD partition: (a) selected (set to 1); (b) filter; and (c) custom-data
18 (for AD, the configuration logic 142 copies sign-and-seal, preferred-dcs, dc-failover, login-
19 domain, and login-user). (3) If the CD still has partitions that have not been matched up, the
20 configuration logic 142 brings up a dialog interface that allows users to manually match up
21 unmatched SELECTED partitions in the configuration file with unmatched CD partitions. In
22 this matching process, the configuration logic 142 will pre-match by partition name (if
23 provided) to assist the user. The user can undo these approximate matches or accept them and
24 match other pairs as well. (Fig. 9 illustrates this procedure by showing a step 922 of automatic
25

1 matching, a step 924 of assessing whether there are any unmatched partitions, and a step 926
2 of manually matching any assessed unmatched partitions.) (4) For the matches that the user
3 finally decides on, MA-specific configuration logic 142 will propagate partition details from
4 the configuration file partition to the CD partition. These details can include: selected (set to
5 1); filter (where it is assumed that the container structure is the same on the test forest as the
6 production forest; since the domain DN's may differ, the configuration logic 142 will manage
7 the inclusion/exclusion lists appropriately); custom-data (for AD, if there is exact domain-to-
8 domain match-up, the configuration logic 142 copies sign-and-seal, preferred-dcs, dc-failover,
9 login-domain, and login-user; for iPlanet, the configuration logic 122 copies ssl-bind,
10 providing similar behavior for Exchange). (5) The user need not match all the partitions in
11 the file. If the user cancels a matching session, the configuration logic 142 will ask the user
12 whether the user wants to quit creating the MA or wants to go on ignoring the unmatched
13 partitions in the file.

14 For File MA's, the configuration logic 142 copies all File MA partitions to the new
15 MA and marks these as SELECTED.

16 For other MA's, the configuration logic 142 should have a single default partition in
17 the file as well as in the new MA. The configuration logic 142 copies the filter element of the
18 file to the CD partition.

19 In general, in all cases, the configuration logic 142 generates a new GUID for the id of
20 the partition in the new MA. In one implementation, it never reuses the partition id's found in
21 the configuration file.

22 Finally, substep 928 involves processing run profile configuration information
23 provided in the ma-data. The following considerations apply to the execution of this substep.

24 (1) The configuration logic 142 scans the run profiles in the configuration file which only refer
25

1 to MATCHED, SELECTED file partitions. It copies those run profiles to the new MA
2 configuration, making appropriate modifications based on information obtained from the
3 matching CD partition. For instance, configuration logic 142 will change the partition name
4 specified in the file to the partition name of the associated CD partition. (2) The configuration
5 logic 142 does not copy run profiles from the file which refer to either UNMATCHED or
6 UNSELECTED file partitions. (3) In one implementation, in all cases, the configuration logic
7 142 generates a new GUID for the id of a run profile propagated to the new MA. It does not
8 reuse the run profile id's found in the file.

9 Having completed the processing of the ma-data, the process 900 advances to the
10 processing of the mv-data in step 904. The following considerations apply to the processing
11 performed in this step (904). (1) If any of the import attribute flow rules are incompatible with
12 the MA or MV schema, the configuration logic 142 will bring up the import attribute flow
13 property page so that the user can manually address the problem. (2) The configuration logic
14 142 appends the import attribute flow rules in the file to the import attribute flow
15 configuration of the production system 106. If any of these rules flow into the same MV
16 attribute as an existing import attribute flow rule for another MA, the configuration logic 142
17 assigns these lower precedence.

19 **Updating an MA**

20 Fig. 10 describes a process 1000 for updating a new version of an MA design using a
21 file produced by exporting an MA from the lab environment 104. This allows users to
22 iteratively make changes in the lab environment 104 to a single MA, test these changes, and
23 then transfer the changes to the MA on the target production system 106.
24
25

1 In one implementation, the user applies the process 1000 to a specific MA identified
2 by the user. That is, in this implementation, the configuration logic 142 does not
3 automatically perform a search to match information in the configuration file with an MA in
4 the system 106 (although, in another implementation, matching can be performed). In using
5 this process 1000, there is an expectation that the MV schema elements referred to by the
6 exported configured file agree with the MV schema of the target production system 106.
7 Errors may be produced if this assumption does not hold true; for instance, the update of an
8 MA may fail halfway through without restoring the original design of the MA. The user
9 should in general perform a full new import/reevaluate rules run when the user updates a new
10 version of the MA design, but the process need not require deletion of connector space to
11 execute the process.

12 By way of overview, the process 1000 involves replacing the configuration of the
13 existing MA with information provided in the configuration file. As shown in Fig. 10, the
14 process 1000 includes the general steps of comparing flow rules 1002, processing ma-data
15 1004, and inserting new import attribute flow rules 1006. The following discussion clarifies
16 the purpose of each of these steps.

17
18 In step 1002, the configuration logic 142 compares the import attribute flow rules
19 specified in the file with those rules currently applied to the MA in the target production
20 system 106. For the MA under consideration, the configuration logic 142 removes any flow
21 rule present in the target production system 106 that differs from a counterpart rule in the
22 configuration file (except for precedence). This process leaves a subset of rules specified in
23 the configuration file (the “new” rules) that do not match any rule in the target production
24
25

1 system. The configuration logic 142 reserves these non-matching rules so that they can be
2 added in a later stage in the process.

3 The step 1004 of processing ma-data includes multiple subprocesses to handle
4 individual parts of the ma-data: naming information; versioning information; generic MA rule
5 configuration information; controller configuration information; UI configuration information;
6 private configuration information; encrypted attribute configuration information; partition
7 configuration information; and run profile configuration information. As in the case of Fig. 9,
8 in Fig. 10, step 1004 is expanded in the right side of Fig. 10 to yield box 1004' that shows
9 processing associated with each of these parts. Each of these parts is described below in turn.

10 Substep 1008 involves processing naming information provided by the ma-data. As
11 explained in Section B, the naming information includes elements <id>, <name>, and
12 <category>. As to the <id> element, the configuration logic 142 ignores the id information
13 provided in the configuration file. As to the <name> element, the configuration logic 142
14 determines whether the name identified in the configuration file differs from the name of the
15 MA in the target production system 106. If so, the configuration logic 142 uses the name
16 from the configuration file as the name of the MA. However, if another MA has the same
17 name in the target production system 106, the configuration logic 142 will prompt the user to
18 enter a new name for the MA under consideration. As to the <category> element, in one
19 implementation, the configuration logic 142 requires that the category in the configuration file
20 match the category of the selected MA; otherwise the update will fail.

22 Substep 1010 involves processing version information provided by the ma-data. As
23 explained in Section B, the version information includes the elements of <creation-time>,
24 <last-modification-time>, and <version>. As to the <creation-time> element, the
25

1 configuration logic 142 ignores the time specified in the configuration file. As to the <last-
2 modification-time> element, the configuration logic 142 again ignores the time specified in
3 the configuration file. The configuration logic 142 updates the modification time to a
4 prevailing current time when the update completes. As to the <version> element, the
5 configuration file ignores the version information specified in the file. The configuration logic
6 142 will update the version number when the update completes.

7 Substep 1012 involves processing MA rule configuration information provided in the
8 ma-data. As to the <schema> element associated with the MA rule configuration information,
9 the configuration logic 142 determines the “authoritative” schema (e.g., a schema that will be
10 saved with the MA) based on the following considerations. (1) For call-based MA’s other
11 than database MA’s, the configuration logic 142 regards the schema saved with the MA in the
12 target production system 106 as authoritative. That is, in this case, the configuration logic 142
13 ignores the contents of the configuration file. (2) For File MA’s, the configuration logic 142
14 takes the schema found in the file as authoritative. (3) For MSSQL and ORACLE MA’s, the
15 configuration logic 142 calls the MA to get the schema in the CD and compares it with the
16 schema in the configuration file. In this case, the configuration logic 142 builds the schema
17 from the CD, but if the same column appears in both the CD schema and the file schema, then
18 the configuration logic 142 applies the following logic: (a) if that column is declared to be a
19 “reference” in the configuration file and has a type that permits it to be a reference attribute,
20 the configuration logic 142 will make it a reference; (b) if that column is part of the primary
21 key in the configuration file, it will be part of the primary key in the final schema (and marked
22 as immutable). The configuration logic 142 defines other rule elements from what appears in
23 the configuration file and uses this information to replace counterpart information associated
24 with the MA in the target production system 106. The configuration logic 142 will validate
25

1 these settings against the contents of the authoritative schema and allow the user to correct any
2 mismatches.

3 Substep 1014 involves processing controller configuration information. The
4 configuration logic 142 uses the controller configuration information specified in the
5 configuration file, overwriting the corresponding existing MA information stored in the target
6 production system 106. If the configuration file omits the controller configuration
7 information, the configuration logic 142 assumes that the application protection is “low” and
8 there is no impersonation. The configuration logic 142 applies an MA-specific check to
9 obtain this information. The database MA will check whether it is operating in Windows ®
10 operating system authentication mode. If so, it will compare the user/domain information in
11 the configuration file with the stored information currently associated with the MA. If they
12 differ, the configuration logic 142 can bring up a dialog to obtain the password from the user
13 and call a DBMA support routine to validate the credentials.

14 Substep 1016 involves processing UI configuration information. The configuration
15 logic 142 uses the <description> and <ma-ui-settings> from the configuration file, overwriting
16 the corresponding MA information stored in the target production system 106. In another
17 implementation, the <ma-ui-settings> element settings stored on the target production system
18 106 are regarded as authoritative.

19 Substep 1018 involves processing private configuration information. The
20 configuration logic 142 generally uses the private configuration information specified in the
21 configuration file. For IPLANET and the File MA types, which allow per object anchor
22 configuration, the configuration logic 142 should validate that the attributes in the anchor are
23 defined in the schema and that they are declared immutable. MA-specific callouts should
24 check each pair of credentials (such as “user” for SQL, “security” on DBMA, or
25

1 “domain/user” for AD forest or partition) to see if the credentials differ from that specified in
2 the configuration file and the CD. If so, the configuration logic 142 can bring up password
3 dialogs to prompt the user to enter a password and then call MA-specific validation routines to
4 make sure the password they enter is correct.

5 Substep 1020 involves processing encrypted attribute configuration information. In
6 one implementation, this information is omitted from the configuration file.

7 Substep 1024 involves the processing of partition configuration information in the
8 configuration file. Generally, the configuration logic 142 handles partition information in an
9 MA-specific manner. For LDAP MA's, the following considerations apply to the processing
10 of the configuration file. (1) In the update case, the configuration logic 142 considers the list
11 of saved partitions associated with the MA on the target production system 106 to be the
12 authoritative list of CD partitions. (That is, the configuration logic 142 performs no discovery
13 of the actual partitions present in the CD during update MA. If changes in partitions have
14 occurred, the user should have previously performed the discovery.) The configuration logic
15 142 initially resets each of these partitions to UNSELECTED. Through automatic and
16 manual means, the user attempts to match SELECTED partitions in the file with the CD
17 partitions. When match-ups occur, the configuration logic 142 copies the following
18 information from the file partition to the CD partition: (a) selected (set to 1); (b) filter (it is
19 assumed that the container structure is the same on the test forest as the production forest;
20 since the domain DN's may be different, the configuration logic 142 will manage the
21 inclusion/exclusion lists appropriately); and (c) custom-data (for AD, the configuration logic
22 142 copies sign-and-seal, preferred-dcs, dc-failover, login-domain, and login-user; for iPlanet,
23 the configuration logic 142 copies ssl-bind). (2) The configuration logic 142 does not
24 necessarily require that all the SELECTED file partitions get matched to CD partitions and
25

1 vice versa. The file configuration logic 142 drops file partitions that do not get matched to CD
2 partitions. The configuration logic 142 marks CD partitions that do not get matched as
3 UNSELECTED, but these partitions will nevertheless be saved with the MA.

4 For File MA's, configuration logic 142 regards the partitions in the file as
5 authoritative. One reason not to simply remove all the partitions in the CD is to avoid deleting
6 the CS objects in connector space. Once again, these partitions are generally processed by
7 matching the partitions in the configuration file with those in the CD. In the event that a file
8 partition is matched up with a CD partition, the configuration logic 142 copies over the filter
9 criteria (note that if the filter changes then the configuration logic 142 should mark this
10 partition as needing full import). The configuration logic 142 creates a new partition for any
11 configuration file partition that does not match up. The configuration logic 142 deletes any
12 CD partition that does not match up. This deletion operation may involve bringing up a
13 progress dialog while all the CS objects under it are deleted.

14 Other MA's should have a single default partition in the configuration file as well as in
15 the new MA. This should make matching easy. The filter information associated with the file
16 partition should overwrite the MA filter information. If the filter actually changes, the
17 configuration logic 142 should mark the partition as requiring full import.

18 A partly generic and partly MA-specific technique is used to perform matching
19 between file partitions. The following considerations apply to the process. (1) First, the
20 configuration logic 142 attempts to definitely match up partitions in the file with partitions in
21 the CD by id. This represents an MA-independent matching, but it only works if a user first
22 stores a server configuration on a first server, stores this configuration on another server,
23 changes an MA, and then brings back an export of the modified MA to the first server. (For
24 example, this situation applies when a user first transferred a server configuration from the lab
25

1 system 108 to the production system 106 using the export and import operations. Then, the
2 user modified one of the MA's on the lab system 108 and transferred this MA to the
3 production system 106 using the export and import operations. In this case, the GUID's
4 identifying the partitions would be the same on the lab system 108 as on the production
5 system 106; as a result, it is possible to match the partitions by their GUID's without user
6 intervention.) For all matches found, the configuration logic 142 copies information from the
7 file partition to the CD partition. (2) In the case of an AD using the AD partition GUID, the
8 configuration logic 142 performs an MA-specific match to definitely match each SELECTED
9 partition contained in the file with a single CD partition. (3) If unmatched partitions remain in
10 the CD, the configuration logic 142 brings up a dialog that allows users to manually match up
11 unmatched SELECTED partitions in the configuration file with unmatched CD partitions.
12 The configuration logic 142 will pre-match by partition name (if any) to assist the user. The
13 user can undo these suggested matches or accept these suggestions and match other pairs as
14 well. (Fig. 10 illustrates this procedure by showing a step 1024 of automatic matching, a step
15 1026 of assessing whether there are any unmatched partitions, and a step 1028 of manually
16 matching any assessed unmatched partitions.) (4) The configuration logic 142 permits the
17 user to not match all the partitions in the file. If the user cancels a matching session in
18 progress, the user will be asked whether the user wants to quit creating the MA or wants to
19 continue.

20
21 In one implementation, in all cases, when the configuration logic 142 creates a new
22 partition in the MA, it generates a new GUID for the id of the partition in the new MA. It
23 does not reuse the partition id's found in the configuration file.

24 Substep 1030 involves the processing of run profile configuration information. The
25 following considerations apply to the processing of this information. (1) The configuration

1 logic 142 scans the run profiles in the configuration file to identify the ones which refer to
2 MATCHED, SELECTED file partitions. The configuration logic 142 automatically matches
3 by id these run profiles in the configuration file with counterpart profiles that already exist in
4 the MA. As a fall-back, the configuration logic 142 attempts to match by name. For each pair
5 that match, the configuration logic 142 propagates the information from the file version to the
6 existing MA. The configuration logic 142 creates new run profiles for any run profiles in the
7 configuration file that do not match up. (2) The configuration logic 142 does not copy run
8 profiles from the configuration file which refer to either UNMATCHED or UNSELECTED
9 file partitions. (3) Note that the exemplary technique described above does not remove run
10 profiles currently associated with the MA; the technique creates new run profiles or modifies
11 existing run profiles.

12 After processing the ma-data, the configuration logic 142 advances to step 1006. In
13 this step, configuration logic 142 inserts the “new” import attribute flow rules with lowest
14 precedence into the system configuration. The MA update will fail at this point with the
15 updates from steps 1002 and 1004 if any of the import attribute flow rules are incompatible
16 with the MA or MV schema.

17 **Importing a System Configuration**

18 Figs. 9 and 10 pertain to the importing or updating of individual MA’s. In contrast,
19 Fig. 11 pertains to a process 1100 for configuring the entire system 106. The system 106 may
20 include multiple MA’s associated therewith, collectively governed by a metaverse schema.
21 Because configuring the entire system 106 will involve importing and/or updating individual
22 MA’s, the technique described in Fig. 11 draws upon the processes in Figs. 9 and 10 as
23 component parts thereof. In one implementation, interrupting the configuration of the system
24
25

106 midway through may result in an unreliable configuration state; in this case, the user should retry the process 1100 shown in Fig. 11.

In one exemplary implementation, the process 1100 includes seven principal steps. Step 1102 involves matching up the management agents in the configuration files with those stored on the target production system 106 using id (e.g., GUID). The process 1100 fails if the configuration logic 142 determines that the target production system includes any management agent that is missing from the configuration files. However, the configuration logic 142 permits the case where the configuration files specify additional management agents that are not included in the target production system 106.

In step 1104, the configuration logic 142 removes the import attribute flow rules from the server configuration.

In step 1106, the configuration logic 142 removes the export attribute flow rules from each MA in the target production system.

In step 1108, the configuration logic 142 imports the saved schema specified in the file MV.XML. This operation functions in a non-data-destructive manner like the standalone schema import feature provided by the configuration logic 142 (e.g., for an individual MA). The following considerations apply to the processing provided by step 1108. (1) Object types on the target production system 106 that do not appear in the configuration files are not removed. Object types that appear in the configuration file but do not appear on the target production system are added. (2) Attributes belonging to an object type that do not appear in the file are not removed. Attributes of an object type that appear in the configuration file but not on the target production system 106 are added. (3) If there are simple indexing changes (e.g., whether an indexable attribute is marked “indexed” or “unique-indexed”), the configuration file’s specification of the indexing state is applied to the target production

1 system 106. This step will fail if an attribute in the configuration file has any other schema
2 differences (such as a different type, e.g., when one version is indexable while another is not).

3 In step 1110, the configuration logic 142 applies the following procedure for each MA
4 file in the saved configuration. (1) The configuration logic 142 takes the id of the MA stored
5 in the configuration file and looks for an MA on the system with the same id. (2) If no such
6 MA is found, then the configuration logic 142 creates a new MA using the configuration
7 specified in the configuration file. Processing of ma-data proceeds according to the procedure
8 described above with respect to Fig. 9 ("Importing an MA From File"). However, in this case,
9 the configuration logic 142 creates the MA in the target production system 106 using the id in
10 the configuration file. Further, when the configuration logic 142 creates a partition or run
11 profile that matches with an MA in the configuration file, it should reuse the corresponding
12 id's that are found in the file. (3) On the other hand, if the configuration logic 142 finds a
13 matching MA, then it processes the "ma-data" in the same manner described above with
14 respect to Fig. 10 ("Updating MA From File"). However, in this case, when the configuration
15 logic 142 adds a new partition or run profile that matches with one in the configuration file,
16 the configuration logic 142 should reuse the corresponding id's that are found in the
17 configuration file.

18 In step 1112, the configuration logic 142 places the import attribute flow rules from
19 the configuration file onto the target production system.

20 In step 1114, the configuration logic 142 replaces the object deletion rules (also as
21 known as metaverse or mv deletion rules) on the target production system 106 with the mv-
22 deletion rules in the configuration files.
23
24
25

1 In one exemplary implementation, the process 1100 does not handle DLL extensions.
2 To fully complete the configuration, the user should copy relevant DLLs into an Extensions
3 directory on the target production system.
4

5 **C.4. UI Functionality**

6 Figs. 12-16 shows details regarding an exemplary series of user interface (UI)
7 presentations provided by the administrative logic 512 to facilitate the execution of the
8 procedures described above. These user interface presentations can be displayed on a
9 computer monitor display in a conventional manner. A user can interact with the
10 administrative logic 512 also in a conventional manner, e.g., by entering commands using a
11 keyboard, mouse-type input mechanism, touch screen input mechanism, joy stick, or other
12 input mechanism. This UI functionality provided by the administrative logic 512 can be
13 provided on both the production (target) system 106 and the lab system 108, or on either one
14 of these systems.
15

16 The first UI presentation 1200 shown in Fig. 12 allows the user to enter commands
17 that initiate various stages of the configuration procedure. Namely, a first command field
18 1202 prompts the configuration logic 142 to initiate the export procedure described above. In
19 the export procedure, one or more files are transferred from the lab system 108 to the storage
20 location 138 specified by the user. Accordingly, in one implementation, the UI presentation
21 1200 can be presented on a computer monitor (not shown) associated with the lab system 108,
22 allowing a user who is interacting with that system 108 to transport one or more configuration
23 files to the storage location 138. However, a user at a remote station, such as the production
24
25

1 system 106, can also use the UI presentation 1200 to remotely command the transfer of
2 configuration files from the lab system 108 to the storage location 138.

3 A second command field 1204 allows a user to transfer the files from the storage
4 location 138 into the production system 106 where they are incorporated into the relevant
5 databases of the production system 106. The user that initiates the import command can be
6 the same user that initiated the export command, or a different user.

7 Another UI presentation 1300 shown in Fig. 13 allows the user to specify a directory
8 location that can be used to implement the storage location 138. More specifically, the UI
9 presentation 1300 can be used to initially specify the directory location where one or more
10 configuration files are to be stored in the course of an export operation. Also, the UI
11 presentation 1300 can be used to inform the import process of the directory location that
12 already stores one or more configuration files provided by the export process. In the
13 exemplary case shown in Fig. 13, a folder 1302 within a directory of folders 1304 is used to
14 store the configuration files.

15
16 Once the import procedure is underway, another UI presentation 1400 shown in Fig.
17 14 can be used to monitor the progress of the configuration process. Namely, an input
18 directory field 1402 identifies the location of the configuration files that are driving the
19 configuration process. A progress field 1404 presents real time feedback regarding the
20 progress of the configuration process. Namely, the configuration logic 142 forwards
21 notifications regarding when it has commenced and finished different parts of the
22 configuration process. The progress log receives these notifications and displays the names of
23 the parts that have commenced or finished. The user can be kept apprised of the progress of
24 the configuration of the production system 106 by monitoring the progress field 1404. In the
25

1 event of an error that halts the configuration of the production system 106, the progress field
2 1404 provides information that can quickly pinpoint the part of the configuration task that may
3 have caused the error.

4 The UI presentation 1500 shown in Fig. 15 prompts the user to enter credential
5 information. This UI presentation 1500 may come into play at different junctures in the
6 configuration procedure. In one case, the configuration logic 142 may prompt the user to
7 enter credential information to implement the creation of a specific new MA. More
8 specifically, consider the case in which the user imports an MA (or the configuration logic 142
9 determines that a new MA needs to be created in the course of performing the import server
10 configuration process). In this case, the configuration logic 142 will need to connect to the
11 CD that the MA interacts with in order to determine the partitions that this CD employs. To
12 perform this function, the configuration logic 142 requires the credentials used to connect to
13 the associated CD. The UI presentation 1500 is used to obtain such credentials, which are
14 subsequently used to access the CD. These credentials are also saved along with the
15 configuration of the new MA. After configuration of the MA, these stored credentials can be
16 used in importing and exporting data to and from the MA during the normal use of the
17 metadirectory service.
18

19 The above-identified credential information can include a user name (provided in field
20 1502) and a password (provided in field 1504). A forest name (provided in field 1506) and a
21 domain name (provided in field 1508) provide other identifying information used in granting a
22 user permission to a CD.
23

24 The UI presentation 1600 shown in Fig. 16 provides a mechanism for matching
25 partitions. That is, during the import or updating of an MA, the configuration logic 142

1 attempts to match partitions specified in the configuration information 136 with partitions that
2 already exist (e.g., as reflected by information associated with the existing MA provided on
3 the production system 106 or actual partitions used in the associated connected directory
4 source (CD). The configuration logic 142 may be able to automatically match some of the
5 partitions specified in the configuration information 136 with existing partitions (e.g., by id,
6 name, and/or on some other basis). However, the configuration logic 142 may be
7 unsuccessful in matching other partitions specified in the configuration information 136. The
8 UI presentation 1600 displays these file-specified and existing partitions and allows a user to
9 manipulate these partitions and the associations between these partitions.

10 More specifically, field 1602 shows unmatched partitions as specified in the
11 configuration information 136. Field 1604 shows unmatched partitions reflected in the
12 existing MA. Field 1606 shows the association between file-specified and existing partitions.
13 (If the checkbox beneath the field 1606 is checked, then the field 1606 only presents pairs of
14 partitions that have been automatically matched by the configuration logic 142, reflected by
15 the operational label of "Exact Match" that appears in a column of this field.) Command
16 button 1608, 1610, and 1612 allow a user to modify the designations of partitions and/or
17 modify the association between partitions. For example, the "New" command button 1608
18 allows a user to designate a partition in field 1602 as new, to indicate that this partition is not
19 present in the existing set of partitions. The result of designating a file-specified partition as
20 "new" can be reflected in the field 1606 by showing this new partition with the operational
21 label of "New." The "Match" command button 1610 allows a user to add a selected pair of
22 partitions that appear in fields 1602 and 1604 to the field 1606 as manually matched partitions.
23 The result of manually matching a selected pair in fields 1602 and 1604 can be reflected in the
24 field 1606 by showing the manually matched pair with the operational label of "Manual
25

1 Match.” The “Delete” command button 1612 allows a user to delete/deselect a partition in the
2 exiting partitions field 1604 (because, for instance, it describes a partition that will no longer
3 exist after the configuration operation has completed). The result of designating an existing
4 partition as deleted can be reflected in the field 1606 by showing this deleted partition with the
5 operational label of “Deleted.” The “Remove” command button 1614 allows a user to undo
6 the effects of any of the command buttons 1608, 1610, or 1612. Further, the configuration
7 logic 142 may have erroneously matched a file-specified partition with an existing partition.
8 In this case, the user can undo this automatic match using the “Remove” command button
9 1614, whereupon this pair of partitions will appear in fields 1602 and 1604 to be processed by
10 the user in manual fashion. Generally, the user can select partitions and actuate command
11 buttons in conventional fashion by using a graphical input device, such as a mouse, or some
12 other input device.

13 14 **D. Exemplary Computer Environment for Implementing the Configuration** 15 **Techniques**

16
17 Fig. 17 shows an exemplary computer environment 1700 that can be used to
18 implement the metadirectory system and/or the configuration logic 142. The computing
19 environment 1700 includes the general purpose computer 1702 and display device 1704.
20 However, the computing environment 1700 can include other kinds of computer and network
21 architectures. For example, although not shown, the computer environment 1700 can include
22 hand-held or laptop devices, set top boxes, programmable consumer electronics, mainframe
23 computers, gaming consoles, etc. Further, Fig. 17 shows objects of the computer environment
24 1700 grouped together to facilitate discussion. However, the computing environment 1700
25

1 can employ a distributed processing configuration. In a distributed computing environment,
2 computing resources can be physically dispersed throughout the environment.

3 Exemplary computer 1702 includes one or more processors or processing units
4 1706, a system memory 1708, and a bus 1710. The bus 1710 connects various system
5 components together. For instance, the bus 1710 connects the processor 1706 to the
6 system memory 1708. The bus 1710 can be implemented using any kind of bus structure
7 or combination of bus structures, including a memory bus or memory controller, a
8 peripheral bus, an accelerated graphics port, and a processor or local bus using any of a
9 variety of bus architectures. For example, such architectures can include an Industry
10 Standard Architecture (ISA) bus, a Micro Channel Architecture (MCA) bus, an Enhanced
11 ISA (EISA) bus, a Video Electronics Standards Association (VESA) local bus, and a
12 Peripheral Component Interconnects (PCI) bus also known as a Mezzanine bus.

13 Computer 1702 can also include a variety of computer readable media, including
14 a variety of types of volatile and non-volatile media, each of which can be removable or
15 non-removable. For example, system memory 1708 includes computer readable media in
16 the form of volatile memory, such as random access memory (RAM) 1712, and non-
17 volatile memory, such as read only memory (ROM) 1714. ROM 1714 includes an
18 input/output system (BIOS) 1716 that contains the basic routines that help to transfer
19 information between objects within computer 1702, such as during start-up. RAM 1712
20 typically contains data and/or program modules in a form that can be quickly accessed by
21 processing unit 1706.

22 Other kinds of computer storage media include a hard disk drive 1716 for reading
23 from and writing to a non-removable, non-volatile magnetic media, a magnetic disk drive
24 1718 for reading from and writing to a removable, non-volatile magnetic disk 1720 (e.g.,
25

1 a “floppy disk”), and an optical disk drive 1720 for reading from and/or writing to a
2 removable, non-volatile optical disk 1724 such as a CD-ROM, DVD-ROM, or other
3 optical media. The hard disk drive 1716, magnetic disk drive 1718, and optical disk drive
4 1722 are each connected to the system bus 1710 by one or more data media interfaces
5 1726. Alternatively, the hard disk drive 1716, magnetic disk drive 1718, and optical disk
6 drive 1722 can be connected to the system bus 1710 by a SCSI interface (not shown), or
7 other coupling mechanism. Although not shown, the computer 1702 can include other
8 types of computer readable media, such as magnetic cassettes or other magnetic storage
9 devices, flash memory cards, CD-ROM, digital versatile disks (DVD) or other optical
10 storage, electrically erasable programmable read-only memory (EEPROM), etc.

11 Generally, the above-identified computer readable media provide non-volatile
12 storage of computer readable instructions, data structures, program modules, and other
13 data for use by computer 1702. For instance, the readable media can store the operating
14 system 1728, one or more application programs 1730, other program modules 1732, and
15 program data 1734.

16 The computer environment 1700 can include a variety of input devices. For
17 instance, the computer environment 1700 includes the keyboard 1736 and a pointing
18 device 1738 (e.g., a “mouse”) for entering commands and information into computer
19 1702. The computer environment 1700 can include other input devices (not illustrated),
20 such as a microphone, joystick, game pad, satellite dish, serial port, scanner, card reading
21 devices, digital or video camera, etc. Input/output interfaces 1740 couple the input
22 devices to the processing unit 1706. More generally, input devices can be coupled to the
23 computer 1702 through any kind of interface and bus structures, such as a parallel port,
24 serial port, game port, universal serial bus (USB) port, etc.
25

1 The computer environment 1700 also includes the display device 1704. A video
2 adapter 1742 couples the display device 1704 to the bus 1710. In addition to the display
3 device 1704, the computer environment 1700 can include other output peripheral devices,
4 such as speakers (not shown), a printer (not shown), etc.

5 Computer 1702 can operate in a networked environment using logical connections
6 to one or more remote computers, such as a remote computing device 1744. The remote
7 computing device 1744 can comprise any kind of computer equipment, including a
8 general purpose personal computer, portable computer, a server, a router, a network
9 computer, a peer device or other common network node, etc. Remote computing device
10 1744 can include all of the features discussed above with respect to computer 1702, or
11 some subset thereof.

12 Any type of network can be used to couple the computer 1702 with remote
13 computing device 1744, such as a local area network (LAN) 1746, or a wide area
14 network (WAN) 1748 (such as the Internet). When implemented in a LAN networking
15 environment, the computer 1702 connects to local network 1746 via a network interface
16 or adapter 1750. When implemented in a WAN networking environment, the computer
17 1702 can connect to the WAN 1748 via a modem 1752 or other connection strategy. The
18 modem 1752 can be located internal or external to computer 1702, and can be connected
19 to the bus 1710 via serial I/O interfaces 1754 other appropriate coupling mechanism.

20 Although not illustrated, the computing environment 1700 can provide wireless
21 communication functionality for connecting computer 1702 with remote computing
22 device 1744 (e.g., via modulated radio signals, modulated infrared signals, etc.).

23 In a networked environment, the computer 1702 can draw from program modules
24 stored in a remote memory storage device 1756. Generally, the depiction of program
25

modules as discrete blocks in Fig. 17 serves only to facilitate discussion; in actuality, the programs modules can be distributed over the computing environment 1700, and this distribution can change in a dynamic fashion as the modules are executed by the processing unit 1706.

Wherever physically stored, one or more memory modules 1708, 1720, 1724, etc. can be provided to store the various rules, objects, schemas, etc. described above.

E. Appendix: Exemplary Schemas and Rules

The following appendix, which forms an integral part of this specification, provides various rules and schemas used in the metadirectory service.

E.1. Join Rules

Referring to the generic MA rule configuration schema shown above, the <join> sub-element governs how a metadirectory synchronization engine should join an object in the metadirectory buffer to an object in the metadirectory core. In one implementation, a join operation involves searching the metadirectory core for an object that corresponds to an object in the metadirectory buffer, and then linking the corresponding objects.

In one implementation, joining two objects involves establishing a link between the two objects that enables subsequent attribute flow to occur between the two objects. Until a metadirectory buffer object is joined to a metadirectory core object, the metadirectory buffer object does not affect the metadirectory core because no relationship to the metadirectory core exists. After a metadirectory buffer object is joined to a metadirectory core object, the buffer object can affect the core object (and vice versa) in various ways, examples of which are discussed in more detail herein.

1 In one implementation, when an object is received by the metadirectory buffer, an
2 attempt is made to join the metadirectory buffer object to an object in the metadirectory core.
3 If an object exists in the core that corresponds to the buffer object, the two objects will be
4 joined. In cases where no corresponding object can be found in the metadirectory core, a new
5 core object is projected (if enabled by the core projection rules and the run configuration rules)
6 and the metadirectory buffer object is automatically joined to the new core object. The join
7 rules are also applied during “apply rules runs” that apply to pending updates to the
8 metadirectory core when a disconnector object in the metadirectory buffer is changed to a
9 connector object.

10 Maintenance processing may be employed to re-evaluate all existing joins against the
11 defined join rules, as well as to evaluate normal disconnectors for potential joining. During
12 both updating and maintenance processing, explicit disconnectors (those created with account
13 joiner or buffer deprovisioning rules) are not evaluated for joining and will remain as
14 disconnectors. In one implementation, whenever a normal disconnector object is run through
15 the connector filter the object will be projected and/or joined to a core object if the
16 disconnector object passes the filter.

17 A join is performed for a metadirectory buffer object by initiating a search for objects
18 in the metadirectory core that match defined search criterion. Any join candidates found
19 during the search are then passed to a resolution handler to perform validation of the result (in
20 the case of a single join candidate) or to identify a single join target (in the case of multiple
21 join candidates). After a metadirectory core object has been identified as the join target, the
22 metadirectory core object is joined to the metadirectory buffer object. In one implementation,
23 the join rules specify the search criterion, the method of join resolution/validation, handling of
24 ambiguous results, and scoping of join rules by CD object types.
25

Exemplary join rules for an MA are expressed in XML and specify criterion for joining two objects. In one implementation, the user defines the join rules through a UI that will create and store these rules in XML on the metadirectory server. The rules engine will employ these stored rules in the course of executing join actions initiated by either a MA run or by account joiner. Exemplary join rules for an MA can be defined in a declarative manner, with provision for programmatic rules via a user-written script where complexity requires it. Exemplary XML Join rules schema is shown below:

```
<join >
  <join-profile cd-object-type="cdObjectType">
    <join-criterion id="GUID1">joinCriterion1</join-criterion>
    <join-criterion id="GUID2">joinCriterion2</join-criterion>
    <join-criterion id="GUID3">joinCriterion3</join-criterion>
    ...
  </join-profile>
  ...
</join >
```

The <join> element can encapsulate multiple <join-profile> elements. Each <join-profile> specifies the join search criterion that are specific to a particular object type. Users, for example, might be configured with one <join-profile>, whereas contacts might be configured with a different profile.

Each <join-profile> specifies the object type to which it applies to by means of a "cd-object-type" attribute. In a particular implementation, only one <join-profile> is allowed with the same "cd-object-type." Within each <join-profile>, multiple <join-criterion> elements can be configured with an implicit priority order (i.e., a prioritized "or" exists between each <join-criterion>). An exemplary join process evaluates each <join-criterion> in priority sequence in search of a join target until either a single join target is identified or the search is exhausted and no join target has been identified.

1 Within a `<join-profile>` element, the `<join_criterion>` element is responsible for
2 configuring the search criterion as well as the method of join resolution. In a particular
3 implementation, each `<join-criterion>` operates independently as there is no relationship
4 between `<join-criterion>` searches. The following exemplary `<join_criterion>` schema
5 illustrates join criterion:

```
6        <join-criterion id="GUID">  
7            <collation-order>CollationOrder string</collation-order>  
8            <search mv-object-type="mvObjectType">  
9                <attribute-mapping  
10                    intrinsisc-attribute=(true | false)  
11                    mv-attribute="mvAttributeName">  
12                        attributeMapping  
13                    </attribute-mapping>  
14                    ...  
15                </search>  
16                <resolution type=(none | scripted)>  
17                    <script-context>contextString</script-context>  
18                </resolution>  
19        </join-criterion>
```

20 In the `<join-criterion>` schema above, the “id” for `<join-criterion>` is a GUID that
21 uniquely identifies the join criterion rule (e.g., “{934A9523-A3CA-4BC5-ADA0-
22 D6D95D979429}”). In one implementation of the metadirectory, the UI will generate a
23 GUID and set it as an attribute of the join-criteria element when a new one is added.

24 The exemplary `<collation-order>` element specifies how any string comparisons that
25 need to be done by the search should be performed by an SQL Server. For each locale id there
26 is generally more than one collation order that the user can choose, allowing the user to choose
27 whether to be case insensitive, accent insensitive, and the like. The `<collation-order>` tag is
28 optional and defaults to the default SQL Server collation for an exemplary metadirectory
29 database.

The exemplary <search> element specifies a set of AND-ed conditions on the values of the metadirectory core object being searched for. Each condition is specified by an <attribute-mapping> element. The exemplary content of the <attribute-mapping> element, “attributeMapping,” may be a direct or scripted attribute mapping fragment such as:

```
<direct-mapping>
  <src-attribute>cdAttributeName</src-attribute>
</direct-mapping>
```

or

```
<scripted-mapping>
  <src-attribute>cdAttributeName</src-attribute>
  ...
  <script-context>contextString</script-context>
</scripted-mapping>
```

Although these mappings have the same syntax as used in attribute flow, the semantic meaning is different. Each mapping means that a value(s) from the metadirectory buffer attribute (direct-mapping) or a calculated value(s) (script-mapping) is compared to the metadirectory core attribute given by “mv-attribute” according to the table below. There is an optional Boolean attribute “intrinsic-attribute” used to signify that the metadirectory core attribute designated by the “mv-attribute” attribute is an “intrinsic” metadirectory attribute (not an attribute in the schema, but metadata exposed by metadirectory for an object). The default value for the “intrinsic-attribute” attribute is “false.”

Table 1 illustrates exemplary actions to take in response to successful comparisons of attributes in objects from remote repositories to attributes from objects in the metadirectory core.

Table 1

Remote Repository Attribute	Core object attribute	Successful comparison
Direct mapping of single valued attribute in RR	Single valued core attribute	RR attribute value equals the core attribute value
Direct mapping of multi-valued attribute in RR	Single valued core attribute	One of RR attribute values equal to the core attribute value
Direct mapping of single valued attribute in RR	Multi-valued core attribute	RR attribute value equal to one of the core attribute values
Direct mapping of multi-valued attribute in RR	Multi-valued core attribute	One of RR attribute values equal to one of the core attribute values
Scripted mapping generates a single value	Single valued core attribute	Scripted value equals the core attribute value
Scripted mapping generates multiple values	Single value core attribute	One of scripted values equals the core attribute value
Scripted mapping generates a single value	Multi-valued core attribute	Scripted value equals one of the core attribute values
Scripted mapping generates multiple values	Multi-valued core attributes	One of the scripted values equals one of the core attribute values

In this implementation, “equality” includes different conditions, depending on the types of values being compared. As an example, equality of strings is based on the collation-order set for the criterion, whereas binary and integer comparisons test for exact value matches.

In an exemplary implementation, the object search can be further scoped by specifying an “mv-object-type.” The “mv-object-type” attribute is optional. If it is omitted, then the object type will match all core object types. The search element includes one or more mapping sub-elements. The <resolution> sub-element is used when the “type” attribute is “scripted.” The <resolution> sub-element indicates that a user-written script entry point

1 should be called to validate a single result or pick between multiple search results coming
2 back from the search. The actual script will be defined in the scripting object for the MA. The
3 user-defined <script-context> string allows the script to determine the context in which it has
4 been invoked (i.e., from which <join-criterion> element). The callout to the script will return
5 a BOOL to indicate whether the join target has been successfully resolved. It will also be
6 possible to return a new object type for the metadirectory core object in the case of successful
7 comparison. If the script is unable to resolve the join target because of further ambiguous
8 results, then an exception may be issued.

9 In one implementation, the <resolution> element is mandatory. The <resolution>
10 element may specify a desired resolution script, or the <resolution> element may be left empty
11 with “type” set to “none.” An exemplary resolution script has the following parameter list:

- 12
- 13 ▪ IN: buffer object to join
- 14 ▪ IN: join criterion context string so the script knows how it is being invoked
- 15 ▪ IN: array of core join candidates
- 16 ▪ OUT: index of the resolved join target in the core join candidates array
- 17 ▪ OUT: optional authoritative core object type to be updated on join target
- 18

19 The optional core object type parameter is employed when the resolution script has the
20 ability to determine updates to the object type of the core join target object. This ability might
21 be beneficial in interforest-type scenarios where temporary placeholder objects (e.g., a
22 “contact”) may be initially imported into the core from a non-authoritative source, and it may
23 be desirable to have the authoritative source override the object type when joining to it (e.g.,
24 change a “contact” to a “user”).
25

When a resolution script indicates that the object type of the core object must change, the connector object in the buffer is joined to the core object. Subsequently, all attribute values contributed by the metadirectory buffer objects joined to a core object, will be recalled, the object type of the core object will be changed, and attributes will be re-imported from all the buffer objects joined to the core object. After doing so, provisioning and export flow processes are performed.

An ambiguous result may occur if multiple potential join candidate objects are found during the join search and a single join target object cannot be identified. In one implementation, if the <join-criterion> ends with such ambiguous results, or no results, the join process will advance to the next <join-criterion>.

To further illustrate the join rules schema, another detailed exemplary join rules schema is shown below:

```
<join >
  <join-profile cd-object-type="user">
    <join-criterion id="{934A9523-A3CA-4BC5-ADA0-
      D6D95D979429}">
      <search mv-object-type="user">
        <attribute-mapping mv-attribute="uid">
          <direct-mapping>
            <src-attribute>empId</src-attribute>
          </direct-mapping>
        </attribute-mapping>
        <attribute-mapping mv-attribute="company">
          <constant-mapping>
            <constant-value>Microsoft</constant-value>
          </constant-mapping>
        </attribute-mapping>
      </search>
      <resolution type="scripted">
        <script-context>Criterion1</script-context>
      </resolution>
    </join-criterion>
    <join-criterion id="{534A9523-A3CA-4BC5-ADA0-
      D6D95D979425}">
      <search mv-object-type="user">
        <attribute-mapping mv-attribute="mail">
          <direct-mapping>
            <src-attribute>alias</src-attribute>
          </direct-mapping>
```

```

1         </attribute-mapping>
2         </search>
3         <resolution type="scripted">
4             <script-context>Criterion2</script-context>
5         </resolution>
6     </join-criterion>
7 </join-profile>
8 <join-profile cd-object-type="prov-user">
9     <join-criterion id="{5C875108-D0CD-471a-9D9C-
10     BC3E9C2C4A12}">
11         <search mv-object-type="user">
12             <attribute-mapping intrinsic-attribute="true" mv-
13             attribute="object-id">
14                 <direct-mapping>
15                     <src-attribute>mv-object-id</src-attribute>
16                 </direct-mapping>
17             </attribute-mapping>
18         </search>
19         <resolution type="none"/>
20     </join-criterion>
21 </join-profile>
22 <join-profile cd-object-type="contact">
23     <join-criterion id="{134A9523-A3CA-4BC5-ADA0-
24     D6D95D979421}">
25         <search mv-object-type="user">
26             <attribute-mapping intrinsic-attribute="false"
27             mv-attribute="mail">
28                 <direct-mapping>
29                     <src-attribute>mail</src-attribute>
30                 </direct-mapping>
31             </attribute-mapping>
32         </search>
33         <resolution type="none"/>
34     </join-criterion>
35 </join-profile>
36 </join >

```

E.2. Projection Rules

The projection rules schema specifies how metadirectory buffer objects, if any, are projected as new entries in the core. As described herein, an exemplary metadirectory includes a core synchronization engine and a rules engine for employing the projection rules. Such an implementation provides for separation of the rules logic from the synchronization duties, thereby dividing up tasks among distinct modules that specialize in those tasks.

1 In an exemplary metadirectory implementation, a set of projection rules is associated
2 with an MA. Projection rules specify the manner in which metadirectory buffer objects are
3 projected into the metadirectory core. Projections rules may be defined either in a declarative
4 manner, or programmatically via a user-written script. When the user defines the rules
5 declaratively the mappings may be specified by the user in the configuration UI.

6 In a particular implementation, the projection rules specify enabling and/or disabling
7 projection of buffer space objects into the core space, declaratively mapping of remote
8 repository objects into core space object types, and/or programmatically projecting objects via
9 user-written script(s).

10 In a particular implementation, two properties are set when creating a new
11 metadirectory core object: a distinguished name (DN) and an object type. In this
12 implementation, the DN may be a persistent system generated GUID. The projection rules
13 may specify whether an object is to be projected from a remote repository into the
14 metadirectory core, and, if so, the appropriate object type to employ for the projection of
15 objects from. Exemplary object type mappings (discussed further below) specify types which
16 indicate whether a mapping is prohibited, scripted, or declarative. Thus, the projection rules
17 are an exemplary mechanism by which object type mappings can be specified.

18 Declarative mappings allow a user to specify types of metadirectory core objects that
19 should be created when a given remote repository object type is to be projected. Each
20 declarative mapping is an object type pair that identifies both a source remote repository
21 object type and a destination metadirectory core object type. Such declarative mappings may
22 be one-to-one mappings or many-to-one mappings. An example of a many-to-one mapping is
23 a mapping of both "employee" object types and "contact" object types to a "user" object type
24 in the core. A many-to-one mapping may be accomplished by employing two distinct
25

1 mappings (e.g., one mapping for “employee” to “user,” and another for mapping “contact” to
2 “user”).

3 A user-written script can be used in scenarios where simple declarative mappings are
4 not sufficient to determine the metadirectory core object type. An exemplary implementation
5 of a mapping script accepts a metadirectory buffer object as input and, based on the object
6 type and/or attributes, the script determines an appropriate metadirectory core object type.
7 The mapping script may also selectively determine whether or not to project a buffer object
8 into the core.

9 The following exemplary pseudo-schema outlines how the projection rules may be
10 configured in XML:

```
11  
12 <projection>  
13   <class-mapping id="GUID" cd-object-type="cdClass"  
14     type={ "none" | "declared" | "scripted" }>  
15     <mv-object-type>mvClass</mv-object-type>  
16   </class-mapping>  
17   ... additional <class-mapping> elements ...  
18 </projection>
```

16 A particular implementation of a projection rule schema includes an ID GUID
17 associated with the mapping rule, <class-mapping>. The GUID may be used to identify
18 lineage properties on the associated object for object change tracking purposes. The UI
19 randomly generates these GUIDs as the user modifies/creates the projection rules.

20 If the type is “scripted” then a user-written script determines whether to project and, if
21 so, the appropriate object type to employ. Note that the name of the script method is not
22 specified in the schema shown above. However, in a particular implementation, there may be
23 a specified naming convention (e.g., method named Project(), etc.) that a customer may follow
24 when authoring a script. An exemplary script has the following parameter list:
25

- IN: CS object to project
- OUT: TRUE/FALSE projection status
- OUT: MV object type if projected

In exemplary projecting rules, if the type is “none” the imported objects will be staged in the metadirectory buffer as normal disconnectors, but will not be projected into metadirectory core.

To further illustrate the projection rules, the following exemplary detailed schema may be used to implement projection rules:

```
<projection>
  <class-mapping type="declared"
    id="{934A9523-A3CA-4BC5-ADA0-D6D95D979429}"
    cd-object-type="contact">
    <mv-object-type>user</mv-object-type>
  </class-mapping>
  <class-mapping type="declared"
    id="{734A9523-A3CA-4BC5-ADA0-D6D95D979427}"
    cd-object-type="user">
    <mv-object-type>user</mv-object-type>
  </class-mapping>
  <class-mapping type="declared"
    id="{534A9523-A3CA-4BC5-ADA0-D6D95D979425}"
    cd-object-type="group">
    <mv-object-type>group</mv-object-type>
  </class-mapping>
</projection>
```

The foregoing example demonstrates a many-to-one mapping where both the remote repository object types “contact” and “user” are mapped to the metadirectory core “user” object type. Additionally, the remote repository object type “group” is to be mapped to the metadirectory core object type “group.”

The following provides an example of how a user-written script can be configured to control buffer to core projection:

```
<projection>
  <class-mapping type="scripted"
    id="{934A9523-A3CA-4BC5-ADA0-D6D95D97942A}"
    cd-object-type="contact">
```

```
1      </class-mapping>  
2      </projection>
```

3 In the above example case, the rules specify that a script should be called to project
4 objects received from a remote repository that have a “contact” object type. Note that in the
5 scripted case, the mv-object-type element is not specified.

6 The following provides an example of how to configure the projection rules to disable
7 projection into the metadirectory core:

```
8      <projection>  
9          <class-mapping type="none"  
10              id="{934A9523-A3CA-4BC5-ADA0-D6D95D97942A}"  
11              cd-object-type="contact"/>  
12      </projection>
```

13 In the above example, the rules specify that remote repository “contact” object
14 type should not be projected into the metadirectory core.

15 **E.3. Stay Disconnecter Rules**

16 This subsection describes an XML format of the stay disconnecter rules. The stay
17 disconnecter (SD) rules describe a rules engine filter that is employed by the sync engine
18 during the process of importing/exporting objects. The SD filter is scoped by object type and
19 has the ability to express filtering conditions based on characteristics of the imported object.

20 The exemplary semantics of the SD rules are as defined by the following
21 considerations: (1) When an object is first imported, it is evaluated against the SD filter before
22 join/projection is attempted. If the object satisfies the filter, then the sync engine will mark
23 that object as a normal disconnecter and will not attempt to join/project the object.
24 Conversely, if the object does not satisfy the filter, then the sync engine will pursue
25 join/projection actions for the object. (2) As deltas to the object are imported, the SD filter

will be reevaluated regardless of whether the object is currently a disconnecter or a connector. If it is a normal connector, and it now satisfies the filter criteria, the join will be broken and it will be turned into a normal disconnecter. If it is a normal disconnecter and it no longer satisfies the criteria, it will be sent through the join/project rules for processing. (3) A reapply-rules run will apply the SD filter to all normal connectors and disconnecters, handling them as described in the preceding paragraph. (4) The SD filter is not applied to explicit connectors/disconnecters because their explicit status exempts them. (5) When any one of the following export scenarios occurs, the SD filter will be applied to the outgoing CS object before it is pushed out to the connected directory: a new object is provisioned; an object rename occurs; or export attribute flow is performed. If the CS object satisfies the SD filter, then an error will be generated and the transaction will be rolled back. This is done to maintain data consistency by avoiding the export of changes to a connected directory that would lead to subsequent disconnection when objects are re-imported.

The stay disconnecter rules are encapsulated in a top-level <stay-disconnector> element which may contain multiple children <filter-set> elements, each of which specify filter conditions for specific CD object types.

The following provides the full XML format for these rules. Each portion will be discussed in detail individually in the sections that follow.

```
<stay-disconnector>
```

```
  <filter-set cd-object-type="cdObjectType" type=(declared |
scripted) id="guid">
```

```
    <filter-alternative id="guid">
```

```
      <condition cd-attribute="attributeName"
intrinsic-attribute=(true | false)
operator=(equality |
inequality |
less-than |
less-than-or-equal |
greater-than |
```

```

1         greater-than-or-equal |
2         present |
3         not-present |
4         substring-start |
5         not-substring-start |
6         substring-end |
7         not-substring-end |
8         substring-any |
9         not-substring-any |
10        bit-on |
11        bit-off )>
12        <value ui-radix="radix">operandValue</value>
13    </condition>
14    ...
15 </filter-alternative>
16
17    ...
18 </filter-set>
19 ...
20 </stay-disconnector>

```

The stay disconnector rules are configured within a top-level <stay-disconnector> element. The following provides a high-level outline of how these rules are structured in XML:

```

14 <stay-disconnector>
15     <filter-set cd-object-type="cdObjectType1" type=(declared |
16     scripted) id="guid">
17         <filter-alternative>filterConditions1</filter-alternative>
18         <filter-alternative>filterConditions2</filter-alternative>
19         <filter-alternative>filterConditions3</filter-alternative>
20         ...
21     </filter-set>
22
23     <filter-set cd-object-type="cdObjectType2" type=(declared |
24     scripted) id="guid">
25         ...
26     </filter-set>
27
28     ...
29 </stay-disconnector>

```

The <stay-disconnector> element may encapsulate multiple <filter-set> child elements. An undefined filter or an empty <stay-disconnector> element (e.g., one with no

1 children) means that no filtering is configured and that join/projection is attempted on all
2 imported objects.

3 Each <filter-set> element describes filtering conditions for a specific CD object type
4 as configured by the attribute “cd-object-type.” Each <filter-set> should be configured as
5 either declarative or scripted by setting the attribute “type” to either “declared” or “scripted,”
6 respectively. The “id” attribute is optional and its presence depends on the configured “type”
7 as described below.

8 A declarative <filter-set> is configured with one or more <filter-alternative> child
9 elements and, in one exemplary implementation, should have no “id” attribute (instead, it is
10 specified within each child <filter-alternative> for declarative). Each <filter-alternative>
11 defines a series of conditions involving the DN and/or attributes of an imported object. An
12 object is said to satisfy a <filter-alternative> if the object’s DN and attributes meet all the
13 defined conditions. An implicit “or” exists between all <filter-alternative> elements, such that
14 an object need only satisfy one alternative in order to satisfy the filter.

15 A scripted <filter-set> is used in scenarios where simple declarative rules are
16 insufficient to describe the filtering requirements and is expressed as an empty <filter-set>
17 element (i.e., it does not have any <filter-alternative> child nodes). A scripted <filter-set>
18 should specify an “id” attribute that uniquely identifies the rule and its value should be a
19 GUID in brace format (e.g., “{534A9523-A3CA-4BC5-ADA0-D6D95D979425}”). The
20 user-written script will take a CS object as input and will determine if the object satisfies the
21 filter based on the CD properties of the object. The script will have this parameter list:

- 22 ▪ IN: CS object
- 23 ▪ OUT: Boolean status indicating whether the filter was satisfied.
- 24
- 25

1 The filtering process will apply the appropriate <filter-set> based on the object type of
2 the imported object. If no applicable <filter-set> is found, then no filtering is performed on the
3 object and the sync engine will proceed to attempt join/projection. However, if an appropriate
4 <filter-set> has been identified then the imported object is either evaluated against each
5 <filter-alternative> (if declarative), or passed to the user-written script for evaluation (if
6 scripted). If the imported object satisfies the filter, then the sync engine will mark the object in
7 the CS as a normal disconnector without attempting join/projection. Conversely, if the filter is
8 not satisfied, then the normal join/projection process will be attempted for the object.

9 The <filter-alternative> element encapsulates a set of logical conditions expressed in
10 XML that is used to evaluate the suitability of an object for processing based on its attribute
11 values and/or DN. If the object satisfies every condition, then a TRUE result is yielded and
12 the alternative is considered to have been satisfied.

13 These conditions are expressed in this exemplary format:

```
14  
15       <filter-alternative id="guid">  
16               <condition cd-attribute="attributeName1 "  
17               operator="operation">attrValue1</condition>  
18               <condition cd-attribute="attributeName2 "  
19               operator="operation">attrValue2</condition>  
20               <condition cd-attribute="attributeName3 "  
21               operator="operation">attrValue3</condition>  
22               ...  
23       </filter-alternative>
```

24 The "id" attribute uniquely identifies the filter alternative and its value should be a
25 GUID in brace format (eg. "{534A9523-A3CA-4BC5-ADA0-D6D95D979425}"). No two
filter alternatives may have the same value for the "id" attribute.

1 The application of an individual condition can yield a TRUE result if the object meets
2 the condition, or a FALSE result if it does not. The condition expressions are effectively
3 and'ed together in order to compute an overall result for the <filter-alternative>. That is, all
4 child node conditions should resolve to TRUE in order for the <filter-alternative> to be
5 satisfied.

6 Filter conditions are logical expressions that describe the attribute or DN requirements
7 that an object should satisfy. If the object satisfies the requirements, then a TRUE result is
8 yielded.

9 The filter conditions are expressed in the following exemplary format:

```
11       <condition    cd-attribute="attributeName"  
                    intrinsic-attribute=(true | false)  
                    operator=(equality |  
12                            inequality |  
                            less-than |  
13                            less-than-or-equal |  
                            greater-than |  
14                            greater-than-or-equal |  
                            present |  
15                            not-present |  
                            substring-start |  
16                            not-substring-start |  
                            substring-end |  
17                            not-substring-end |  
                            substring-any |  
18                            not-substring-any |  
                            bit-on |  
                            bit-off )>  
19       <value   ui-radix="radix">operandValue</value>  
      </condition>
```

21 “cd-attribute” identifies the directory attribute to which the condition applies.
22 Supported attribute types are string, reference-based*, numeric, and Boolean. “intrinsic-
23 attribute” is set to “true” if “cd-attribute” identifies an MMS-intrinsic attribute, namely “dn.”
24 By default, “intrinsic-attribute” is “false.” The “operator” attribute defines the operation to
25 perform. The general purpose “equality” and “inequality” operators allow for direct

1 comparison of the complete DN or attribute of an object against a specified value. They apply
2 to both string and non-string attributes. The “less-than,” “less-than-or-equal,” “greater-than,”
3 and “greater-than-or-equal” operators apply to numeric attributes only and allow the attributes
4 of an object to be compared against a specified value.

5 To test for the presence or absence of an attribute from an object, the respective
6 “present” and “not-present” operators can be used. For these operators, the <value> element
7 should be empty or unspecified.

8 If only a portion of a string attribute or the DN is of interest, then the “substring-start”
9 or “substring-end” operators can be employed to check for equality at the start or end,
10 respectively. To match any part of a string attribute, the “substring-any” operator can be
11 employed for this purpose. Negative substring operators are also available, namely “not-
12 substring-start,” “not-substring-end,” and “not-substring-any.” All string comparisons are
13 case insensitive and accent sensitive.

14 The bitwise operators “bit-on” and “bit-off” allow individual bits of a numeric
15 attribute to be checked against a bit mask that is specified by the <value> element. In the case
16 of the former, a TRUE condition is obtained if the attribute value “and”ed with the bit mask
17 yields a result equal to the bit mask, whereas the latter operation is TRUE if the “and”
18 operation yields 0.

19 In cases where the attribute value is absent in the imported object, a condition
20 involving an “inequality” operator or any of the “not” prefixed operators will resolve to
21 TRUE, whereas all other operators will resolve to FALSE.

22 The contents of the <value> element specify one of the operands employed in the
23 comparison (the other operand is sourced from the object itself). When specifying a value for
24 a numeric attribute type, the value should be expressed in hex format with a “0x” prefix. The
25

“ui-radix” attribute allows the UI to preserve the radix in which user numeric data was originally entered. This is required so that the UI can redisplay the value to the user in the original radix because the actual value is stored internally in hex. When dealing with multi-valued attributes, the condition is interpreted as a test to determine if any value in the object matches that specified by the <value> element. For the “bit-on” and “bit-off” operators, the <value> element specifies the bit mask used in the operation.

The following provides an example of the <stay-disconnector> element.

```

<stay-disconnector>
  <filter-set cd-object-type="contact" type="declared">
    <filter-alternative id="{234A9523-A3CA-4BC5-ADA0-
      D6D95D979422}">
      <condition cd-attribute="employeeID" intrinsic-
        attribute="false" operator="not-present">
        <value/>
      </condition>
    </filter-alternative>
    <filter-alternative id="{334A9523-A3CA-4BC5-ADA0-
      D6D95D979423}">
      <condition cd-attribute="rdn" intrinsic-
        attribute="false" operator="equality">
        <value>Jane Doe</value>
      </condition>
    </filter-alternative>
    <filter-alternative id="{434A9523-A3CA-4BC5-ADA0-
      D6D95D979424}">
      <condition cd-attribute="dn" intrinsic-
        attribute="true" operator="equality">
        <value>cn=Jane Doe,o=Microsoft</value>
      </condition>
    </filter-alternative>
  </filter-set>

  <filter-set cd-object-type="user" type="declared">
    <filter-alternative id="{534A9523-A3CA-4BC5-ADA0-
      D6D95D979425}">
      <condition cd-attribute="title" operator="substring-
        start">
        <value>administrator</value>
      </condition>
      <condition cd-attribute="company" operator="equality">
        <value>Microsoft</value>
      </condition>
    </filter-alternative>

    <filter-alternative id="{634A9523-A3CA-4BC5-ADA0-
      D6D95D979426}">
      <condition cd-attribute="mail" operator="equality">

```

```

1         <value>administrator@Microsoft.com</value>
2     </condition>
3 </filter-alternative>
4
5     <!-- filter out if not a normal account (0x200) -->
6     <filter-alternative id="{734A9523-A3CA-4BC5-ADA0-
7 D6D95D979427}">
8         <condition cd-attribute="userAccountControl"
9         operator="bit-off">
10             <value ui-radix="16">0x200</value>
11         </condition>
12     </filter-alternative>
13
14     <!-- filter out if a disabled account (0x2) -->
15     <filter-alternative id="{834A9523-A3CA-4BC5-ADA0-
16 D6D95D979428}">
17         <condition cd-attribute="userAccountControl"
18         operator="bit-on">
19             <value ui-radix="10">0x2</value>
20         </condition>
21     </filter-alternative>
22 </filter-set>
23
24 <filter-set cd-object-type="organization"
25     type="scripted"
26     id="{934A9523-A3CA-4BC5-ADA0-D6D95D979429}"/>
27
28 <filter-set cd-object-type="organizationalUnit"
29     type="scripted"
30     id="{A34A9523-A3CA-4BC5-ADA0-D6D95D97942A}"/>
31
32 </stay-disconnector>

```

E.4. Import Attribute Flow XML Format and Runtime Behavior

An exemplary <import-attribute-flow> element includes rules or script, which govern how attributes on objects in the metadirectory buffer are imported to objects in the metadirectory core. Import attribute flow (IAF) rules describe how attribute values should flow from metadirectory buffer objects to linked metadirectory core objects. They are declared in metadirectory core-centric fashion, so that all import flows for all MAs may be defined in one document.

At the lowest level of exemplary IAF rules is a mapping, which describes how to generate a destination attribute value given a set of source attribute values. At the next level is a flow, which encapsulates the mapping, providing metadata (a unique ID) and criteria by

source MA and source buffer object type (primary object class). Flows are then grouped and
scoped by destination core attribute and, finally, groups of flows are then grouped into flow
sets and defined by destination core object type. Thus, a flow ends up defining a relationship
between a single destination core attribute and any number of source buffer attributes from a
single object type. More details are given in the sections below.

An exemplary `<import-attribute-flow>` element specifies import attribute flow (IAF)
rules. Within an exemplary `<import-attribute-flow>` are defined multiple flow sets, which
describe the attribute flows or associations for a particular set of metadirectory buffer and
metadirectory core object types. An exemplary `<import-attribute-flow>` element is given
below:

```
<import-attribute-flow>
  <import-flow-set mv-object-type="object type">
    <import-flows mv-attribute="attribute name" type="ranked">

      <import-flow src-ma="guid" cd-object-type="object type"
        id="guid">
        <direct-mapping>
          <src-attribute>attribute name</src-attribute>
        </direct-mapping>
      </import-flow>

      <import-flow src-ma="guid" cd-object-type="object type"
        id="guid">
        <direct-mapping>
          <src-attribute intrinsic="true">dn</src-attribute>
        </direct-mapping>
      </import-flow>

      <import-flow src-ma="guid" cd-object-type="object type"
        id="guid">
        <scripted-mapping>
          <src-attribute>attribute name</src-attribute>
          <src-attribute>attribute name</src-attribute>
          <script-context>context string</script-context>
        </scripted-mapping>
      </import-flow>

      <import-flow src-ma="guid" cd-object-type="object type"
        id="guid">
        <constant-mapping>
          <constant-value>value</constant-value>
        </constant-mapping>
      </import-flow>
```

```

1      <import-flow src-ma="guid" cd-object-type="object type"
      id="guid">
2          <dn-part-mapping>
              <dn-part>part index</dn-part>
            </dn-part-mapping>
3        </import-flow>
      ...
4    </import-flows>
    <import-flows mv-attribute="attribute name" type="ranked">
5      ...
    </import-flows>
    ...
6  </import-flow-set>
  <import-flow-set mv-object-type="object type">
7    ...
  </import-flow-set>
  ...
8 </import-attribute-flow>

```

In a particular implementation, IAF mappings describe how to generate a destination metadirectory core attribute value (or values) given a set of source metadirectory buffer attribute values. Four exemplary types of mappings are direct, scripted, constant, and Distinguished Name-part. Each type of mapping has an associated element type: <direct-mapping>, <scripted-mapping>, <constant-mapping>, and <dn-part-mapping>, respectively. Examples of such elements are shown below:

```

16    <direct-mapping>
      <src-attribute>attribute name</src-attribute>
17    </direct-mapping>

18    <direct-mapping>
      <src-attribute intrinsic="true">dn</src-attribute>
19    </direct-mapping>

20    <scripted-mapping>
      <src-attribute>attribute name</src-attribute>
      <src-attribute>attribute name</src-attribute>
21    <src-attribute intrinsic="true">dn</src-attribute>
      <script-context>context string</script-context>
22    </scripted-mapping>

23    <constant-mapping>
      <constant-value>value</constant-value>
24    </constant-mapping>

25    <dn-part-mapping>
      <dn-part>part index</dn-part>

```

1 </dn-part-mapping>

2 Exemplary flows encapsulate mappings, providing metadata (a unique ID) and
3 scoping by source MA and source buffer object type. Flows are defined via the <import-
4 flow> element, which should have exactly one mapping sub-element. An exemplary <import-
5 flow> elements defines the attributes *src-ma*, *cd-object-type*, and *id*. Below is an example of
6 an <import-flow> element:

```
7           <import-flow src-ma="guid" cd-object-type="object type"  
8           id="guid">  
9            <direct-mapping>  
10            <src-attribute>attribute name</src-attribute>  
11            </direct-mapping>  
12           </import-flow>
```

13 Within the top-level <import-attribute-flow> element can be multiple <import-flow-
14 set> elements, which themselves can contain multiple <import-flows> elements. The
15 <import-flows> elements can then contain any number of <import-flow> elements. Taken
16 together, the <import-flow-set> and <import-flows> elements define child flow declarations
17 by destination core object type and destination core attribute. Exemplary <import-flow-set>
18 and <import-flows> attribute elements are shown below:

```
19           <import-flow-set mv-object-type="object type">  
20            <import-flows mv-attribute="attribute name" type="ranked">  
21            <import-flow src-ma="guid" cd-object-type="object  
22            type" id="guid">  
23            ...  
24            </import-flow>  
25            ...  
26           </import-flows>  
27           ...  
28           </import-flow-set>
```

E.5. Export Attribute Flow XML

The export-attribute-flow element may be used to specify how values of attributes on metadirectory core objects should be flown back to connected metadirectory buffer objects (i.e., be exported). Export attribute flow (EAF) rules describe how attribute values should flow from core objects to linked buffer objects. In one implementation, the EAF rules are declared in an MA-centric fashion, and thus, may be specified for each MA.

In an exemplary implementation, the EAF rules provide a mapping, which describes how to generate a destination attribute value given a set of source attribute values. The EAF rules may also provide a flow, which encapsulates the mapping, providing metadata (a unique ID and mapping configuration) and scoping based on the destination attribute. Attribute flows are grouped into flow sets, wherein the groups are based on source object type and destination object type. Thus, a flow can be used to define a relationship between a single destination attribute in the metadirectory buffer, and any number of source attributes from a single object type in the metadirectory core.

Exemplary export attribute flow (EAF) rules may be encapsulated in a top-level <export-attribute-flow > element. Multiple flow sets are defined within the <export-attribute-flow > element. The flow sets define how object types in the metadirectory buffer are related to object types in the metadirectory core. To illustrate and exemplary <export-attribute-flow > format, an XML schema is shown below:

```
<export-attribute-flow>
  <export-flow-set cd-object-type="object type" mv-object-
    type="object type">
    <export-flow cd-attribute="attribute name"
      id="guid"
      suppress-deletions="true">
      <direct-mapping>
        <src-attribute>attribute name</src-attribute>
      </direct-mapping>
```

```

1      </export-flow>
2      <export-flow cd-attribute="attribute name" id="guid">
3          <direct-mapping>
4              <src-attribute intrinsic="true">object-id</src-
5                  attribute>
6              </direct-mapping>
7          </export-flow>
8          <export-flow cd-attribute="attribute name" id="guid">
9              <scripted-mapping>
10                 <src-attribute>attribute name</src-attribute>
11                 <src-attribute>attribute name</src-attribute>
12                 <script-context>context string</script-context>
13             </scripted-mapping>
14         </export-flow>
15         <export-flow cd-attribute="attribute name" id="guid">
16             <constant-mapping>
17                 <constant-value>value</constant-value>
18             </constant-mapping>
19         </export-flow>
20         ...
21     </export-flow-set>
22     <export-flow-set cd-object-type="object type" mv-object-
23         type="object type">
24         ...
25     </export-flow-set>
26     ...
27 </export-attribute-flow>

```

Exemplary <export-attribute-flow > mappings describe how to generate a destination metadirectory buffer attribute value (or values) given one or more source metadirectory core attribute values. Three exemplary types of mappings are shown: direct, scripted, and constant. Each type of mapping has an associated XML element: <direct-mapping>, <scripted-mapping>, and <constant-mapping>, respectively. A general format for attribute mappings is illustrated in the following exemplary schemas:

```

20     <direct-mapping>
21         <src-attribute>attribute name</src-attribute>
22     </direct-mapping>
23     <direct-mapping>
24         <src-attribute intrinsic="true">object-id</src-attribute>
25     </direct-mapping>
26
27     <scripted-mapping>
28         <src-attribute>attribute name</src-attribute>
29         <src-attribute>attribute name</src-attribute>
30         <src-attribute intrinsic="true">object-id</src-attribute>
31         <script-context>context string</script-context>
32     </scripted-mapping>

```

```
1      <constant-mapping>
2          <constant-value>value</constant-value>
3      </constant-mapping>
```

Flows encapsulate mappings, providing metadata (a unique ID and mapping configuration) and scoping by destination CS attribute. In one implementation, flows are defined via the <export-flow> element, which may have a mapping sub-element. Exemplary <export-flow> elements may define the attributes cd-attribute and id, and may optionally define the attribute suppress-deletions. Below is an example of an <export-flow> element XML.

```
10
11      <export-flow cd-attribute="attribute name" id="guid" suppress-
12      deletions="false">
13          <direct-mapping>
14              <src-attribute>attribute name</src-attribute>
15          </direct-mapping>
16      </export-flow>
```

The exemplary cd-attribute attribute provides scoping for the mapping sub-element by defining the mapping's destination metadirectory buffer attribute associated with the mapping. The value of cd-attribute may be the name of a schema-defined buffer attribute that is a member of the destination buffer object type (as defined by the <export-flow-set> element-see below) or an auxiliary class that can possibly be found associated with the destination buffer object type.

Associated with each exemplary mapping is metadata that may be used to identify and configure the mapping. A unique GUID ID associated with a mapping is defined by an id attribute whose value may be a GUID in normal brace format (i.e., "{66069022-6C8C-4d90-A706-17B96A70A4F9}"). This mapping ID may be used when tracking rules contributions during preview mode runs.

1 In one implementation, a mapping configuration indicates whether or not deletions
2 should be suppressed for the mapping; i.e., whether or not NULL values and deletions on
3 source attributes are to be transferred to destination attributes as a delete or
4 suppressed/ignored. This configuration option may be specified via the optional suppress-
5 deletions attribute, which may take on the values "true" and "false," the default being "false."
6 Exemplary actions taken based on mapping configurations are discussed in further detail
7 below.

8 Within an exemplary top-level <export-attribute-flow> element can be one or more
9 <export-flow-set> elements, each of which can contain one or more <export-flow> elements.
10 The <export-flow-set> elements act to define child flow declarations by a source
11 metadirectory core object type and destination metadirectory buffer object type. The
12 following exemplary schema illustrate an exemplary <export-flow> element:

```
13  
14 <export-flow-set cd-object-type="object type" mv-object-  
15 type="object type">  
16 <export-flow cd-attribute="attribute name" id="guid">  
17 ...  
18 </export-flow>  
19 ...  
20 </export-flow-set>  
21  
22  
23  
24  
25
```

19 Flow and mapping sub-elements of the <export-flow-set> element define flows or
20 relationships between a metadirectory buffer object type and metadirectory core object type
21 pair. More specifically, the exemplary <export-flow-set> element shown above defines cd-
22 object-type and mv-object-type attributes that serve to define the scope of sub-elements by
23 source metadirectory core object type and destination metadirectory buffer object type. In an
24 exemplary implementation, the value of the cd-object-type attribute is the name of a buffer
25

object type defined in a destination MA's schema, and the value of the mv-object-type attribute is the name of an object type defined in the core schema (described in further detail below). In one implementation, each flow set corresponds to one source core object type and one destination buffer object type. An exemplary <export-attribute-flow> element is shown below in XML:

```
<export-attribute-flow>
  <export-flow-set cd-object-type="User" mv-object-
    type="person">
    <export-flow cd-attribute="email"
      id="{9E691F4E-4301-4112-B964-CE7E8A\F7CAC}"
      suppress-deletions="true">
      <direct-mapping>
        <src-attribute>email</src-attribute>
      </direct-mapping>
    </export-flow>
    <export-flow cd-attribute="description"
      id="{8F15B855-0517-40f8-9AE9-0565600C0017}">
      <scripted-mapping>
        <src-attribute>email</src-attribute>
        <src-attribute>description</src-attribute>
        <script-context>contextString</script-context>
      </scripted-mapping>
    </export-flow>
    <export-flow cd-attribute="uid"
      id="{DCC92CCA-A2DA-4060-8605-78755F072616}">
      <direct-mapping>
        <src-attribute intrinsic="true">object-id</src-
          attribute>
      </direct-mapping>
    </export-flow>
  </export-flow-set>

  <export-flow-set cd-object-type="Contact" mv-object-
    type="person">
    <export-flow cd-attribute="linked"
      id="{A3D569E9-5DD9-4ece-8AB6-4A4BA4b5554A}">
      <constant-mapping>
        <constant-value>some value</constant-value>
      </constant-mapping>
    </export-flow>
  </export-flow-set>
</export-attribute-flow>
```

As discussed, mappings defined in the <export-attribute-flow> elements, a destination buffer attribute value (or values) may be generated, based on one or more source core attribute values. In one exemplary implementation, EAF mappings include a "suppress deletions"

1 configuration option that can be used to keep NULL values and deletes from flowing from the
2 core to the buffer. The behavior of this option is detailed below in the section entitled “EAF
3 Operations.” The EAF element may or may not be used to validate calculated destination
4 values against a destination remote repository schema. For example, pending exports may be
5 compared to objects/values in a remote repository schema by requesting a buffer object. A
6 user can perform such a validation check if an object fails to export, to determine why the
7 failure occurred.

8 A mapping in the <export-attribute-flow> may be a “direct mapping.” More
9 specifically, the intrinsic attribute core object ID may be declared as the source attribute for an
10 EAF direct mapping. In an exemplary implementation, the core object ID is treated a string
11 value that is directly mapped to the associated destination (i.e., buffer object) attribute. For
12 example, individual bytes in a core (source) GUID of "{befa5fc6-1661-47b4-9c34-
13 deff19525cda}" will be formatted as a string prior to being exported to the associated buffer
14 space attribute.

15 Four exemplary operations related to EAF are described below. These exemplary
16 operations include full synchronization, delta synchronization, reference synchronization, and
17 “back-to-source” synchronization. These operations may be referred to as full sync, delta
18 sync, ref sync or ref-retry, and “back-to-source” sync, respectively. In a particular
19 implementation, the synchronization engine (SE) determines when to invoke any of the EAF
20 operations.

21 Full sync may be called the first time a source core object is synchronized to a newly
22 connected destination metadirectory buffer object. The full sync may also be run when
23 running in re-evaluate rules mode. During full sync, all objects and attributes are exported
24 from the metadirectory core to the metadirectory buffer.
25

1 Delta sync may be called when a source metadirectory core object has previously been
2 synchronized to a destination metadirectory buffer object. During a delta sync, only values
3 that have changed in the core object are exported to the corresponding object in the
4 metadirectory buffer.

5 An attribute in a first object in the metadirectory core may reference a second
6 metadirectory core object. If the second metadirectory core object is linked to or unlinked
7 from a metadirectory buffer object, the attribute values (called reference attribute values)
8 related to the first core object may be changed as a result. The ref sync operation may be
9 called to export the reference attribute values to an object in the buffer that corresponds to the
10 first object in the core.

11 Some SE operations that change metadirectory buffer objects (and/or attributes) can
12 trigger another synchronization involving updating the core based on the change in the buffer,
13 and again updating the buffer based on the update to the core. The “back-to-source” sync
14 operation may be called when such a “re-synchronization” occurs. When executing a
15 mapping, all values are flowed from core to metadirectory buffer.

16 The ref sync operation “reverts” updates imported attribute values to match attribute
17 values calculated in the EAF process.

18 For a given source metadirectory core object and destination metadirectory buffer
19 object, an EAF mapping is said to be “in-scope” if the mapping’s source core object type (mv-
20 object-type) and destination buffer object type (cd-object-type) match those of the core and
21 buffer objects, respectively.

22 For a given source core object and destination buffer object, an EAF mapping is said
23 to be “satisfied” if the core object has a value for at least one of the mapping’s source
24 attributes (src-attribute).
25

1 In general, sync operations take a source core object and a destination buffer object as
2 input and attempt to execute in-scope, satisfied mappings to flow attributes from the core
3 object to the buffer object. Each sync operation may differ from the other sync operations
4 with regard to which attributes are considered when checking to determine if a mapping is
5 satisfied, and which values are flowed when executing a direct mapping.

6 When determining which mappings are satisfied during a full sync, all source
7 attributes are considered. When determining which mappings are satisfied during a delta
8 sync, only those source attributes that have a changed value (have a pending delta) are
9 considered. When determining which mappings are satisfied during a ref sync, only those
10 source attributes of reference type are considered.

11 “Export precedence” refers to calculations made to determine if an export flow
12 that overlaps with an import flow will be allowed to execute. The calculation may be
13 made by comparing the precedence of the overlapping import flow with the precedence
14 of the import flow that supplied the values for the core attribute that is the source of the
15 overlapping export flow. Only when the precedence of the source values is higher than
16 that of the overlapping import flow will the export flow be allowed to execute.

17 In one implementation, an export flow and import flow are said to overlap if the
18 export flow has exactly one source attribute which is also the destination attribute for the
19 import flow and/or the destination attribute of the export flow is one of the source
20 attributes of the import flow.
21
22
23
24
25

E.6. Run Configuration XML Format

An exemplary Run Profile Configuration Element in an MA schema section describes “run profiles” defined for the MA. The following schema illustrates an exemplary format for a Run Profile Configuration Element:

```
<ma-run-data>
  <run-configuration>...</run-configuration>
  <run-configuration>...</run-configuration>
  ...
</ma-run-data>
```

In a particular metadirectory implementation, the metadirectory server instantiates a MA run by passing a run configuration XML fragment parameter to an Execute() function in the MA. The XML fragment contains execution parameters describing how the MA should run.

An exemplary run configuration schema is shown in the following XML fragment:

```
<ma-run-data>
  <run-configuration>
    <id> guid </id>
    <name> string </name>
    <creation-time> time (read only) </creation-time>
    <last-modification-time> time (read only) </last-modification-
time>
    <version> integer </version>
    <configuration>
      <step>
        <step-type type="full-import | delta-import | export | apply-
rules">
          <import-subtype> to-file </import-subtype>
          <import-subtype> resume-from-file </import-subtype>
          <import-subtype> to-cs </import-subtype>
          <export-subtype> to-file </export-subtype>
          <export-subtype> resume-from-file </export-subtype>
          <apply-rules-subtype> apply-pending </apply-rules-subtype>
          <apply-rules-subtype> reevaluate-flow-connectors </apply-
rules-subtype>
        </step-type>
        <dropfile-name> string </dropfile-name>
        <threshold>
          <object> integer </object>
        </threshold>
        <partition> string </partition>
```

```

1      <custom-data> XML fragment </custom-data>
2      <step>
3      <step>
4      ...
5      </step>
6      ...
7      </configuration>
8      </run-configuration>
9      <run-configuration>
10     ...
11     </run-configuration>
12 </ma-run-data>

```

Exemplary sub-element <id> is a unique identifier (GUID) associated with the run configuration. Exemplary sub-element <name> is the display name for the run configuration. Exemplary sub-element creation-time is the time (e.g., GMT) at which the run profile was created. Exemplary sub-element last-modification-time is the time (e.g., GMT) when the run profile was last modified. Exemplary sub-element version is the version number (e.g., integer) of the run configuration.

Exemplary sub-element <step> include information about steps and types of steps in the MA run. The user can configure multiple “run profiles” for an MA. Each “run profile” consists of 1 or more steps. Each step may include of an operation involving import, synchronization, or export. Within the <step> sub-element are descriptions associated with one or more types of steps. In the exemplary <step-type> sub-element, possible step-types are “full-import,” “delta-import,” “export,” and “apply rules.” Each step-type can be further described in sub-elements for the particular type. Examples of the step-types and their associated values are given in Table 2, Table 3, and Table 4.

Table 2 illustrates exemplary values that may be used in <import-subtype> and <delta-subtype> sub-elements.

Table 2

Import subtype(s)	Description
None	An import run without any subtype means that the synchronization is from remote repository all the way to the metadirectory core.
to-file	This subtype drops a file during import and stop without staging the import data in metadirectory buffer. With this sub-type, watermark will not be updated for delta import.
Resume-from-file	This subtype resumes an import run from a drop file. With this sub-type, watermark will not be updated for delta import.
to-file, resume-from-file	These subtypes drop an audit file and continue the import run without stopping.
to-cs	This subtype stages the import data in metadirectory buffer and stops the import run.
resume-from-file, to-cs	These subtypes resume an import run from a drop file, stage the import data in metadirectory buffer and stop the import run. With this sub-type, watermark will not be updated for delta import.
to-file, resume-from-file, to-cs	This drops an audit file during import, stages import data in metadirectory buffer and stop the import run.

Table 3 illustrates exemplary values that may be used in <export-subtype> sub-elements.

Table 3

Import subtype(s)	Description
None	An export run without any substep means that the synchronization is from metadirectory buffer all the way to the remote repository.
to-file	This will drop a file during export and stop. With this sub-type, export batch number will not be updated.
resume-from-file	This will resume an export run from a drop file. With this sub-type, export batch number will not be updated.
to-file, resume-from-file	This implies that we will drop an audit file but will not stop at the drop file during an export run.

Table 4 illustrates exemplary values that may be used in <apply-rules-subtype> sub-elements.

Table 4

Import subtype(s)	Description
apply-pending	It attempts to synchronize all connectors with staged pending imports and also attempts to join/project (and flow attributes) on all normal disconnectors even if they have failed to join during previous apply-pending runs.
reevaluate-flow-connectors	It attempts to reevaluate attribute flow for all connectors in metadirectory buffer under this MA.
Reevaluate-join-flow-all	Reevaluate join and attribute flow for all entries in CS (connectors and disconnectors). Explicit connectors/disconnectors will not be reevaluated (can only be changed using account joiner).

An exemplary <dropfile-name> sub-element can be provided, whereby the user may specify the name of a drop file associated with the MA run. In a particular implementation, one file name may be provided per step.

An exemplary <threshold> sub-element is a sync engine threshold for all MAs. In a particular implementation, all of the specified thresholds are given in absolute numbers. Within a <threshold> sub-element, an <object> sub-element specifies the number of objects to process for the run.

An exemplary <partition> sub-element identifies a partition associated with the associated run steps. In a particular implementation, the format of the partition is MA-specific.

An exemplary <custom-data> sub-element contains MA-specific data for an associated step. Exemplary information that can be provided in the <custom-data> sub-element are step custom data, ad-step-data, time-limit, page-size, batch-size, granular-security, bulk-export, and permissive-write.

To further illustrate an exemplary <ma-run-data> element, the following schema is provided. The schema contains a delta import of objects from an Active Directory ® (AD) repository. The delta import data is dropped into a file for audit and then staged in the metadirectory buffer. Then, the run stops so the user can examine the metadirectory buffer to see what will be propagated to the metadirectory core before committing any changes to the core. In this particular example, the drop file path is "C:\temp\test.xml." Also, in this example two thresholds are set and the import run terminates if either one of the thresholds is reached.

```
<ma-run-data>
  <run-configuration>
    <name> My Typical Delta Import </name>
    <id> 934A9523-A3CA-4BC5-ADA0-D6D95D979421 </id>
    <version> 3 </version>
    <configuration>
      <step>
        <step-type type="delta-import">
          <import-subtype> to-file </import-subtype>
          <import-subtype> resume-from-file </import-subtype>
          <import-subtype> to-cs </import-subtype>
        </step-type>
        <dropfile-name> c:\temp\test.xml </dropfile-name>
        <threshold>
          <object> 100 </Object>
          <delete> 20 </Delete>
        </threshold>
        <partition> cn=ssiul,ou=nttest,dc=Microsoft,dc=com
        </partition>
        <custom-data>
          <timeout>1000</timeout>
          <page-size>500</page-size>
        </custom-data>
      </step>
    </configuration>
  </run-configuration>
</ma-run-data>
```

Although some exemplary methods, exemplary devices, exemplary systems, and exemplary schemas have been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the methods, devices, systems, and schemas are not limited to the exemplary embodiments disclosed, but are

capable of numerous rearrangements, modifications and substitutions without departing
from the spirit set forth and defined by the following claims.

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